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Evaluation of year-round forage management systems for beef production

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GENERAL INTRODUCTION

Utilization of forages for beef cow-calf production systems in Iowa is essential. Incorporation of forages that are grazed during the winter can have advantages over that of feeding stored feeds. Winter grazing of forages can lower feed cost associated with stored feed use and positively influence cow responses. However, incorporation of forages for grazing during the winter requires a systematic approach to management that requires consideration of forage type, optimal time of forage use, and cow nutritional requirements. Risks associated with winter grazing include weather and losses in forage nutritive value. Risks can be mediated through supplementation based on cow body condition, and proper management of forage resources. Therefore, grazing systems, which include winter grazing, must also encompass summer forage production and summer grazing. During the summer, calf production, cow rebreeding, and winter forage production occur. Forage management tools such as rotational stocking, hay harvest and extra animals for forage removal can be utilized to optimized summer cattle and forage production parameters. Incorporation of both winter and summer grazing management systems should be used to evaluate grazing system efficacy for beef and forage production.

Thesis Organization

This thesis is organized in the general fashion of a literature review followed by two manuscripts submitted to the Journal of Animal Science for publication. These manuscripts are followed by general conclusions, literature review works cited, two appendices of additional information and acknowledgements.

LITERATURE REVIEW

Cow Energy Requirements

Maintenance requirements of beef cows for energy defined by NRC (1996) is the amount of feed energy intake that will result in no net loss or gain of energy from the tissues of the animal body. However, energy maintenance is not strictly related to maintenance of body fat, body protein, or body weight. This theoretical difference however, does not preclude the study and reporting of the association of the effects of level of energy intake upon cow body fat, body protein, and body weight. A large number of factors affect how the level of energy intake and animal performance is related. Such factors include body weight, breed or genotype, sex, age, season, temperature, physiological state, and previous nutrition NRC (1996).

Relationship of body composition, cow type, and energy requirements

Maintenance as defined by Ferrell and Jenkins (1985) is the feed energy required for zero body energy change (energy stasis) or feed energy required for zero body weight change (weight stasis). Therefore, in mature cow herds, maintenance of requirements comprise the majority of the energy required for cattle production (Gregory, 1972). A review by Smith (1970) observed that 52% of an animal's basal energy expenditure could be traced to cellular metabolism in the liver, gastrointestinal tract, heart, kidney, brain and skin. McBride and Kelly (1990) stated that the majority of the energy expenditure by visceral organs is in five major biochemical processes: ion transport, protein synthesis, protein degradation, substrate cycling, and urea synthesis. In Ferrell and Jenkins (1985), the authors review the use of body composition in the prediction of maintenance energy requirements. They stated that several researchers have shown that body lean mass or protein is highly correlated to maintenance energy expenditures while body fat mass is poorly correlated. Muscle mass and internal organs are components of lean body mass (Solis et al., 1988). Ferrell and Jenkins (1984) concluded that while total energy expenditures by muscle are higher, energy expenditures per unit weight by muscle are low compared to internal organs. Therefore, increases in body protein as a proportion of body weight would not greatly increase maintenance energy requirements. However, increases in the weight of internal organs as a proportion of body weight would increase the maintenance energy requirements of beef cattle. DiCostanzo et al. (1990), however, reported that estimates of ME intake to maintain 1 kg of protein or 1 kg of fat were 192.9 or 20.7 kcal. Therefore, among cows of equal fat masses, cows with larger protein masses had greater energy requirements for maintenance. However, this increased ME requirement may be explained by the findings of Ferrell and Jenkins (1984), and the fact that DiCostanzo et al. (1990) estimated ME intake on equal fat levels and not equivalent BW or $BW^{.75}$.

Several researchers have reviewed maintenance energy requirements of cattle of differing breeds. Ferrell and Jenkins (1984) concluded that energy requirements for zero body weight change differed among cow types. Ferrell and Jenkins (1985) provided an excellent review of the breed and genetic factors that affect cow maintenance requirements. The energy required for maintenance in cows that have higher potentials for milk production (Jersey-cross and Simmental-cross) were found to have higher maintenance requirements than cows with moderate milk potential (Angus-Hereford cross and Charlois-cross; Ferrell and Jenkins, 1985). Cow size, however, did not influence the difference in maintenance requirements if milk production between cow types was similar. Solis et al. (1988) have agreed with the concept that dairy breeds and dairy breed crosses have higher maintenance requirements than beef breeds. The higher maintenance requirements of dairy breeds compared to beef breeds are largely caused by differences in partitioning of body components and body composition. Kempster et al. (1976) concluded that beef breed cattle deposit more subcutaneous fat than internal and intermuscular fat. Thompson et al. (1983) stated that internal fat has a higher maintenance requirement than fat in subcutaneous locations, caused partly by subcutaneous fat's insulatory powers. This insulation would, therefore, cause a negative relationship between fatness and maintenance energy requirements.

Factors influencing energy requirements

Beef cows grazing range and pastures normally undergo cyclic loss and gain in weight because of seasonal variation in availability and quality of forage (Shierly, 1986). Fluctuations in weight and body condition in particular have been reported in grazing cows (Laurenz et al., 1992) and these factors would then have differing influences on the energy requirements of beef cows throughout the year. Therefore, energy requirements of beef cows at any point in the production cycle maybe affected by the cow's previous condition. Results reported by Laurenz (1992) stated that season had significant effects on live BW, empty BW, and components of empty body weight in both Angus and Simmental cattle. Both breeds of cattle were found to mobilize protein during the summer while gaining in body fat and to replenish protein during the winter. Body condition score is an estimation of tissue cover over ribs, spine, pins and hooks, and tail head (Neumann and Lusby 1986) all of which are subcutaneous fat stores. Therefore, the energy requirement to raise a cow's body condition score can be related to the energy required for the accretion of subcutaneous fat. Houghton et al. (1990b) reported that previous condition of beef cows significantly affects the energy requirement of those cows. Changes in body condition score can have both positive and negative affects on the energy requirement of cows in body condition score flux. Ferrell and Jenkins, (1984) and Houghton et al. (1990b) reported that high energy intake increased daily maintenance requirements, NE_m, to maintain high body condition scores, whereas low energy intakes reduced maintenance energy requirements to maintain body condition. Houghton et al. (1990b) found that cows that were initially maintained on high levels of energy intake and switched to low levels of energy intake exhibited more rapid losses of body condition score, body energy and predicted maintenance energy/$BW^{.75}$ than moderately conditioned or thin cows. The NRC (1996) found that a reduced energy intake above maintenance resulted in a greater amount of protein deposition in the gain of growing animals at a particular weight. However, when thin cattle are placed on a high-energy diet, compensatory fat deposition occurs. Swingle et al. (1979) observed that cull cows increased body lipid 45% , cows were then fed high concentrate diets of varying degrees for 38-108 d.

Weather can also have an affect on the energy requirements of grazing beef cows. The NRC (1996) discussed the importance of both the upper critical temperature and lower critical temperature. In general, mature grazing cattle in Iowa are not subjected to upper critical temperatures that would adversely affect production for any great length of time, unlike growing cattle in feedlots. Therefore, the scope of this discussion will be confined to that of cold conditions observed during winter. A number of equations to predict the NE_m for cattle under the influence of cold weather and cold stress and specific equations have been developed (NRC, 1996). Generally, inputs in these equations consist of the previous air temperature, surface area, external insulation, tissue insulation, lower critical temperature, and effective ambient temperature and were used to calculate the total net energy required for maintenance under conditions of cold stress (NE_{mc}). The external insulation value can be profoundly altered by the hair depth of the animal, wind speed, precipitation, mud cover and hide thickness. Young (1975) determined that gestating beef cows fed at recommended maintenance levels for their respective BW and that were in moderate to fat body condition were able to acclimate themselves to conditions of cold stress. Cows that were placed outside for 123 d had increased resting metabolic rates (4.29 kcal/h.kg$^{.75}$) over housed cattle to (3.13 kcal/h.kg$^{.75}$) and shifted downward their thermoneutral zone. Anderson et al. (1983) reported that TDN requirements of cows decreased below published recommendations at a time when average annual temperature increased with little effect of wind speed. In Canada, Jordan et al. (1968) found that the ME requirements of wintering beef cows outside increased by 30-70% because of adverse climatic conditions.

Energy status and production

The energy status of the cow at critical times during the production cycle can have significant effects on cow efficiency (Wiltbank et al., 1962; Tucker et al., 1989). Several researchers have addressed the effect of restricted diet in prepartum heifers and cows. Restriction of energy level of cattle prior to calving resulted in lower calf birth weights than cattle that remained on energy levels at maintenance or above maintenance (Corah et al., 1975; Houghton et al., 1990a; Wiltbank et al., 1962). Jordan et al. (1968) reported that there was no difference in the calf birth weight from cows fed at *ad libitum* level or at 80, 60, or 40% of the *ad libitum* level of corn silage and hay. Both Corah et al. (1975) and Houghton et al. (1990a) observed that lower birth weight calves continued to have lower body weight up to weaning. This effect was still present when cows fed the energy-restricted diet prior to calving were placed on adequate or high-energy diets postpartum.

The levels of milk production by beef cows are difficult to assess compared to those of the dairy cows is (NRC, 1996). Because of this difficulty, relatively little work has been conducted in the areas of milk yield and composition and their relationship to age, breed, stage of lactation, and nutritional status of beef cows. The NRC (1996) has accepted that milk production by beef cattle ranges from 4 to 20 kg/d with the highest values being reported for Holstein or Friesian cows. Furthermore, NRC (1996) has stated that ME is utilized for lactation and maintenance with similar efficiency. Peak milk production according to the NRC, occurs during week nine of lactation and results in net energy requirements from 3.58 to 10.03 Mcal/day. Work by Bartle et al. (1984) showed that Hereford and Hereford x Angus cows increased milk production when fed at 120% of the energy requirements recommended in NRC (1976) compared to 100%. Similar to other researchers, Sinclair et al. (1994) observed increases in milk yield with additional 50 MJ of ME/day over a base level of 80 MJ of ME/day. Cows receiving additional energy in Sinclair (1994), also produced milk with 151 g more milk fat and 85 g more protein. In another study, Sinclair et al. (1998) found that feeding 705 or 820 kJ/day per kg $BW^{.75}$ produced significantly different milk yields (7.71 vs. 6.74 kg/day) and had carry-over effects into the subsequent lactation where differences were even greater. Wright et al. (1994) examined different cattle breeds grazing two different sward heights that produced two different OM intakes. A difference of 5.4 kg forage OM/day increased milk yield by 1.4 kg/d, but decreased protein concentrations. Holloway et al. (1985) observed increases in milk production in cows grazing fescue-legume pastures, which provided extra nutrients over pastures containing only fescue.

Meeting the energy requirements of pregnant cattle is important to ensuring an adequate nutrient supply for proper growth of the fetus and ensuring that the female has adequate energy reserves to calve, lactate, and rebreed within 80 days (NRC, 1996). The Nutrient Requirements of Beef Cattle (NRC, 1996) provides an adequate overview of the factors affecting fetal growth, and energy requirements of the gravid uterus. It is generally assumed that the nutrient needs for pregnancy are proportional to birth weight of the calf and other products of conception.

After gestation and calving, the next reproductive limit for producing cows is rebreeding for the next season. Short et al. (1990) and Dunn and Moss (1992) reported that restricted feeding during late pregnancy could increase the interval from calving to rebreeding. The duration of the interval from calving to rebreeding cannot last longer than 80 days in order to maintain a calving interval less than 365 days. To have a greater opportunity for conception to occur in the 80 days postcalving, the anestrous period should last 60 days or less (NRC, 1996). Houghton et al. (1990a) performed an experiment that specifically addressed the effect of pre- and postpartum energy levels on reproductive performance of cows. Prepartum and postpartum energy levels interacted to affect the postpartum anestrous level. Cows on low pre- and low post-partum energy levels had longer anestrous intervals (73 days) compared to 54 days for low-high, and 67 days for maintenance-low and maintenance-high energy levels. Thirty-three percent of cows fed the low energy level pre-and post-partum had estrus cycles before 30 days compared to 53% for cows that received maintenance or high pre-partum energy levels. Averaged over pre-partum energy levels, high postpartum energy levels increased pregnancy rate by 23%. Body condition score affected the length of the post-partum interval. Thin cows exhibited post-partum intervals before estrus over 80 days which was 28 to 58 days longer than cows in moderate or fleshy body condition. These data suggest that to maintain acceptable rebreeding schedules, cows should be maintained in adequate body condition. However, it was noted that thin cows did have higher first service conception rates compared to fleshy cows. Similarly, Wiltbank et al. (1962) and Zimmerman et al. (1961) found that the occurrence of estrus after calving was significantly influenced by energy feeding level. The level of energy provided before calving appeared to be relatively more important than that post-partum energy level. The interval from calving to first estrus in cows fed low energy levels pre-and post-partum was significantly longer than for cows fed high-high, high-low, and low-high energy treatments. Corah et al. (1975) observed that 41% of heifers on high pre-partum energy level were exhibiting estrus by 40 days post-partum compared to 28% of heifers on low pre-partum energy levels. Sinclair et al. (1994) measured serum progesterone levels in cows fed to calve at different body condition scores. Those authors found that thin cows had higher serum progesterone concentrations that took longer to fall below basal levels. This result may lead to low plasma gonadotropin levels during the early post-partum period which could delay the onset of normal estrus cyclicity (Sinclair et al., 1994). Sinclair et al. (1994) did not observe that post-partum energy level intake affected the post-partum anovulatory period. However, evidence from that study would suggest that fatter cows at calving and cows on high energy levels after calving are more fertile.

<u>Winter Nutritional Management of Beef Cattle</u>

Feed cost is the largest cost in beef cow production systems, amounting to 40-50% of all costs (Strohbehn, 1990). The winter period in cow production systems is generally the time when most of the feed cost is incurred in the Midwest. There exist three main feed resources for winter-feeding: stored feeds, corn crop residues, and stockpiled perennial forages. All of these feed resources have a place and optimal time of utilization.

Stored feeds

In cow production systems during the winter, the majority of stored forage utilized is comprised of harvested hay (Nichols et al., 1990). Other stored feeds such as corn grain, corn silage, haylage, ammoniated straw and various sources of protein are often utilized in limit-feeding regimes in addition to hay or other feed sources. However, in many cases where forages are available, the majority of these other stored feeds are used as supplements.

When hay is utilized as the primary stored forage in cow production systems, it is often in the form of large round bales. As stored forage, large round hay bales are subjected to weathering losses when stored outside and unprotected as commonly done. Large round hay bales, subjected to weather, deteriorate in quality and quantity (Atwal et al. 1984; Brasche and Russell, 1988; Russell and Buxton, 1985) from what was harvested. However, Marley et al. (1976) concluded that bales stored outside maintained their quality better than bales of the same moisture content that were stored inside. Losses of hay quality and quantity may be reduced if the bale is covered by plastic or kept from contact with the underlying soil (Verma and Nelson, 1981, Russell and Buxton, 1985). Concentrations of ADF, ADIN, CP, and NDF concentrations increased and IVDDM concentrations in hay decreased with outside unprotected storage of large round hay bales (Atwal et al., 1984; Brasche and Russell, 1988; Russell and Buxton, 1985).

In addition to losses associated with the storage of large round hay bales, feeding losses occur with large round bales. Losses of hay DM during feeding are largely caused by the unacceptability to the cow of the outside portion of the hay bale caused by weathering effects (Russell and Buxton, 1985). Thus, a portion of the large round hay bale will go unutilized by cows unless forced to consume the entire bale. Often times, complete hay bale utilization is not achievable because hay is fed a drylot with or without a hay ring, placed in a field or pasture where cows are grazing, or unrolled in a field or pasture (Brasche and Russell, 1988). These hay feeding practices all place the hay bales on the ground where the non-selected portion of the hay will become soiled, used for bedding and wasted (Brasche and Russell, 1988). Management practices such as time restricted feeding, and grinding of the bale may decrease the amount of hay wasted when fed as large round hay bales (Brasche and Russell, 1988).

The economic consideration associated with the utilization of stored feeds is one that requires careful attention. Stored feed use, as either a supplement to grazing animals or the winter management system of choice must address first address the requirements of the cow. If the stored feed resource of choice will not adequately meet the dietary requirements of the cow in terms of energy or protein; then there are no benefits from utilizing a supplement (Lusby and Wagner, 1986). However, if the stored feed will meet the cow's requirement but at a high cost then that feed also is not economically feasible. If combinations of stored feeds are to be used then comparisons of the price of dietary energy units should be examined along with an associative effect the feedstuffs may have on each other (Lusby and Wagner, 1986). In a study conducted by D'Souza et al. (1990), management systems that relied completely on hay were the least profitable.

Corn crop residues

Corn crop residues at present are one of the most common ways of feeding beef cows during late fall and winter in Iowa (Russell et al., 1993a). Therefore, corn crop residues offer perhaps the most economical feed resource for beef cow and calf production in the Midwest (Ward, 1978; Klopfenstein et al., 1987; Strohbehn, 1990).

Corn crop residue yields and grain yields have been found to have a close relationship by Perry and Olson (1975). Corn crop residue yields have been observed to vary because hybrid (Hunt et al., 1992) environment, geographic location and whether they were produced on irrigated or dryland systems (Gutierrez-Ornelas and Klopfenstein, 1991). Yields of corn crop residues have varied from 4,605 to 5,761 kg OM/ha (Russell et al., 1993a), 6,222 DM kg/ha (Lamm and Ward, 1981), and 2,737 to 4,982 kg DM/ha for dryland and 5,907 to 8,298 kg DM/ha for irrigated land (Fernandez-Rivera and Klopfenstein, 1989b). Research performed in Nebraska has examined the differential yields of corn plant parts. Results from Lamm and Ward (1981) found dry matter yields of 694, 2,423, 2,536, and 568 kg/ha for grain; husk and leaf; stems; and cobs. Contrasting yields occur between dryland and irrigated corn. Fernandez-Rivera and Klopfenstein, (1989b) and Gutierrez-Ornelas and Klopfenstein, (1991) observed greater dry matter yields of grain, leaf and husk, stem, and cobs in irrigated fields than dryland fields.

Initial corn crop residue chemical quality can be quite variable depending on the proportion of grain, husk, leaves, stem, and cob. Fernandez-Rivera and Klopfenstein (1989b) examined in vitro dry matter disappearance (IVDDM), crude protein (CP), and neutral detergent fiber (NDF) concentrations of the different portions of corn crop residues and the difference between dryland and irrigated corn crop residues. Total IVDDM was greater for dryland (48.5%) than irrigated corn crop residues (46.8%); however leaf and grain IVDDM was greater for residues from irrigated that dryland. Dryland corn crop residues had higher CP levels (6.2%) for all components than irrigated corn crop residues (3.4%). Concentrations of NDF were also higher on irrigated (85%) than dryland corn crop residues (80.7%). Initial composition of corn crop residues reported by Hitz and Russell (1998) in Iowa compare favorably with those of Fernandez-Rivera and Klopfenstein (1989b). However, initial compositions reported by Lamm and Ward (1981) and Gutierrez-Ornelas and Klofpenstein (1994) were 73 and 74% for IVDDM and 8.8 and 9.0% for CP concentrations. The assumption can be made that these authors used divergent corn hybrids for their respective experiments. These results would agree with the work performed by Hunt et al. (1992) in which they determined that corn hybrids bred for grain or silage use have different qualities as it relates to whole plant stover.

Corn crop residues are affected by weather because it no longer is in growing phase. The amount of precipitation that is received during the corn crop grazing period has significant effect on the rate of loss of nutrients (Gutierrez-Ornelas and Klopfenstein, 1991). During grazing, Hitz and Russell (1998), Lamm and Ward (1981), Fernandez-Rivera and Klopfenstein (1989) and Gutierrez-Ornelas and Klopfenstein (1991, 1994) reported losses of IVDMD or in vitro organic matter disappearance (IVOMD) and CP while concentrations of NDF and acid detergent fiber increased. Some of these losses are associated with both removal of nutrients by grazing animals and weather effects. Russell et al. (1993a) reported that 25 and 37% of the loss of OM and IVOMD from ungrazed corn crop residues could be attributed to weather. Hitz and Russell (1998) observed that 8 kg/ha/d of organic matter yield and .08%/d of IVOMD were lost from the ungrazed portion of corn crop residues. Therefore, because of the losses of nutrients from corn crop residues, timely use of corn crop residues is imperative to fully utilize this resource.

Although corn crop residues are an important source of winter forage for both beef cows and weaned calves, there are times that corn crop residues are deficient in required nutrients or snow cover may limit the grazing ability of cattle (Vetter and Ritter, 1975). In many experiments that utilize corn crop residues, the inclusion of a protein supplement has become routine (Ward, 1978; Fernandez-Rivera et al., 1989b; Fernandez-Rivera and Klopfenstein, 1989; Gutierrez-Ornelas and Klopfenstein, 1991, 1994; Russell et al., 1993a). Because of the low CP content, corn crop residues will require protein supplementation when more than maintenance or gains are required for cows and growing calves (Fernandez-Rivera et al, 1989a). The need for supplemental protein becomes greater as corn crop grazing lengthens because the CP level decreases with time due to selective grazing. (Fernandez-Rivera and Klopfenstein, 1989a). In some cases, the use of quality hay may be all that is required for the additional protein requirements (Hitz and Russell, 1998). In other cases, the limit-feeding of an energy source such as corn grain may be all that is required. Fernandez-Rivera et al. (1989b) determined that in growing animals, the use of a ruminal undegradable protein source to supplement corn crop residues would be most beneficial. Gutierrez-Ornelas and Klopfenstein (1994) determined that there was a response to additional protein, however the protein requirements were strongly related to energy intake. Lusby and Wagner, (1986) concluded that when supplemented with high protein levels, intake of low quality roughage will increase when protein is the first-limiting nutrient. However, protein in some cases must be supplemented with supplemental energy to keep the diet in balance and eliminate any associative effects that may occur.

Animal performance, when grazing corn crop residues, can be influenced many factors. Stocking density of calves grazing on corn crop residues caused no difference for gain for calves stocked at 2.47 or 1.54 head/ha (Fernandez-Rivera, 1989a). Klopfenstein et al. (1990) observed similar gains (.66 kg/d) by calves grazing corn crop residues at .5 and .75 animals/.4 ha had lower (.55 kg/d) gains at 1 animal/.4 ha when protein was supplied to meet requirements. Fernandez-Rivera et al. (1989b) observed that as stocking rate increased, daily gain decreased. Russell et al. (1993a) observed greater body weight gains when cows grazed at 1.64 ha/cow compared to .41 and .82 ha/cow. Russell (1990) reported cows gained twice as much BW over 56 days when stocking density was increased from .20 ha/cow/month to .40 ha/cow/month and BW gains more than tripled when stocking density increased from .40 to .81 ha/cow/month. Russell et al. (1993a) examined the effect if stocking system at a stocking density of .41 ha/cow would affect cow weight change. No difference was observed between strip-stocking or continuous stocking systems.

Body weight gains of growing calves are greater on dryland than irrigated corn crop residue fields (Fernendez-Rivera and Klopfenstein, 1989a; Klopfenstein et al. 1990). Calf gains were 180 g/d for dryland compared to 33 g/d for irrigated corn crop residues when supplemented with 213 g/d of protein (Fernendez-Rivera and Klopfenstein, 1989a). Similarly, daily gains of calves grazing dryland corn crop residues were .55 kg/day compared to .49 kg/day for irrigated corn crop residues when stocked at 2.47 animals/ha (Fernandez-Rivera et al., 1989b).

Stockpiled perennial forages

Stockpiling is the accumulation of forage in the field for the grazing at a later time (Fribourg and Bell, 1984). Extending the grazing season through the use of stockpiled forages, reduces the length of the hay-feeding season and amount of hay fed (Gerrish et al., 1994). In the use of stockpiled forage in grazing systems, the quantity of forage production is an important consideration. Three criteria have profound effects on the quantities of stockpiled forage produced: species, fertilization, and length of stockpiling. Cool-season perennial grasses are the predominate types of forage stockpiled for winter use in the Midwest. Cool-season grass species that have been utilized for stockpiling include: tall fescue, smooth bromegrass, orchardgrass, timothy, and reed canarygrass (Wedin and Klopfenstein, 1995). Legumes generally are not stockpiled because most lose their leaves more easily than grasses (Matches and Burns, 1995). However, legumes are often incorporated with grasses (Sheaffer et al., 1990). These legumes could include alfalfa, red clover, white clover, and birdsfoot trefoil. Therefore, while this discussion will focus primarily on grasses, it should be noted that there often exist mixed grass-legume forage stands utilized for stockpiling.

Because, stockpiling of forage for winter begins in the late summer, different grasses respond differently and produce varying amounts of forage. Wolfe (1926) conducted small plot work and measured herbage production of differing grass and combinations. Accumulation of herbage dry matter from August 15 to late fall was greatest for Sheep's fescue and orchardgrass (1,322 kg/ha) with the next highest yield occurring with Kentucky bluegrass and white clover (829 kg/ha). Comparing stockpiled forage production (Archer and Decker, 1977) found that initial fall yield of unfertilized orchardgrass was 160 kg/ha less than tall fescue. Hitz and Russell (1998) found that initial stockpile herbage masses for smooth bromegrass with or without red clover were only slightly greater than tall fescue with alfalfa forages. Allen et al. (1992a) compared three different stockpiled forage combinations. In that experiment, a tall fescue-red clover mixture yielded two times as much herbage mass as orchardgrass-alfalfa which yielded almost 300 kg/ha more than orchardgrass-red clover. During a companion experiment, Allen et al. (1992b) reported that tall fescue fertilized with nitrogen had more than two times greater the herbage yield than tall fescue-red clover and almost three times more herbage yield than tall fescue-alfalfa pastures.

Fertilization of stockpiled grass pastures with nitrogen when stockpiling begins has increased herbage production. Archer and Decker (1977) compared yields of orchardgrass and tall fescue at different nitrogen fertilization rates. With no N fertilization, tall fescue produced 2,211kg/ha, which was not different from orchardgrass. At 50 kg/ha, orchardgrass herbage yield was 2,479 kg/ha, 83 kg/ha greater than tall fescue. When 100 kg/ha of nitrogen was applied, tall fescue suffered a production depression yielding only 1,904 kg/ha compared to 2,654 kg/ha for orchardgrass. In Allen et al. (1992b), the addition of 90 kg/ha of nitrogen to tall fescue more than doubled the herbage production compared to tall fescue-red clover and tall fescue-alfalfa which would be receiving some nitrogen fixation through the incorporation of legumes in the forage. Gerrish et al. (1994) determined that increasing nitrogen fertilization rates increased stockpiled herbage production. As nitrogen fertilization levels increase from 0 to 134 kg/ha, stockpiled tall fescue herbage yields increased by 154%. Timing of the application of nitrogen was also examined. As nitrogen application rate increased from 0 to 134 kg/ha. stockpiled tall fescue yields increased 103, 80 and 39% for fertilization dates of 1, 15, and 29 of August when stockpiling began on August 1.

In general, the longer the stockpiling period, the greater amount of herbage accumulation that will occur. Fribourg and Bell (1984) began stockpiling at three different times: July 1, August 1, and September 1. Stockpiling initiated in July produced the greatest yields with maximal yields reaching 4,400 DM kg/ha in mid-October. Stockpiling initiated on August 1, caused maximal yields of 3,000 DM kg/ha in late October, while September 1 stockpiling caused maximal yields of 1,400 DM kg/ha in early November. For all initiation dates, DM herbage yields began to decline after maximal production was reached. Dry matter herbage yield decline was greatest in forage that began stockpiling in July. Hitz and Russell (1998) in one year allowed smooth bromegrass-red clover forage to stockpile for two months longer than in later two years. Herbage mass accumulation began on June 1 and resulted in 3,280 DM kg/ha compared to 2,012 DM kg/ha in subsequent years when stockpiling began in early August.

The composition of stockpiled forage utilized for fall and winter grazing is influenced by forage species (Allen et al. 1992a) and length of stockpiling (Fribourg and Bell, 1984). The majority of stockpiling research has utilized tall fescue. Research by Archer and Decker (1977) and Hitz and Russell (1998) have, however, examined the herbage quality of stockpiled tall fescue and either orchardgrass or smooth bromegrass-red clover. Archer and Decker (1977) reported in two trials that mean IVDMD in October for tall fescue was 84.7% and IVDDM of orchardgrass was 84.6%. During the fall and early winter, both species lost digestibility. When final samples were taken in late December in trial 1, tall fescue IVDMD was 79% which was significantly greater than the 73% of orchardgrass. Tall fescue, therefore, lost .08% IVDMD/d while orchardgrass lost .13% IVDMD/d over 105 d. In trial 2, IVDMD of tall fescue and orchardgrass were not different with a mean of 81.3% at the termination of the experiment. Level of nitrogen fertilization had no effect on IVDMD in October or in December. It should be noted that these were small plot studies with no effect of grazing to change IVDMD values. Crude protein concentrations of tall fescue and orchardgrass were 17% in October and did not differ between species. By December, tall fescue had lost 3% CP over 105 d compared to 2.1% in orchardgrass. Hitz and Russell (1998) examined differences in tall fescue-alfalfa and smooth bromegrass-red clover mixtures over three grazing seasons. Initial IVOMD values of stockpiled tall fescue-alfalfa were 56% and smooth bromegrass-red clover IVOMD was 51%. Initial CP values were 14% for both tall fescue-alfalfa and smooth bromegrass-red clover. Concentrations of NDF and ADF were 64 and 67% NDF and 37 and 43% ADF for both species. Hitz and Russell (1998) also addressed specific effects of weather on chemical quality of stockpiled forage. Those authors found no difference between forage species in the rate of change of IVOMD (-.10 %/d), CP (0%/d), NDF (+.10%/d), and ADF (+.75%/d). Fribourg and Loveland (1978) reported that changing the initiation of stockpiling from June 1 to September 1, caused CP concentrations to decrease from 12 to 9% while IVDDM concentrations increased from 49 to 62%.

Weather, animal requirements, or forage shortages may necessitate supplementation of animals grazing stockpiled forages (Allen et al. 1992a; Hitz and Russell, Willms et al., 1998). Unlike corn crop residues, stockpiled forages generally do provide adequate protein supply to gestating cows (Hitz and Russell, 1998; NRC, 1996). To maintain desired levels of production and/or weight gain, however protein and/or energy supplementation may be required (Lardy et al., 1999). Supplementation studies utilizing stockpiled cool season forage are lacking. However, valid comparisons may be drawn those studies utilizing range forages with supplementation programs. Rittenhouse et al. (1970), using soybean meal with corn or cornstarch observed, little influence of protein on forage dry matter digestibility (DMD) and intake. Energy supplementation did depress forage intake, but did not affect forage DMD. Although forage intake was depressed with energy supplementation, total dietary intake and DMD increased with incremental increases in supplemental energy. Kartchner (1981) determined that dry matter intake was greater for non-supplemented cows than those supplemented with protein or grain for energy. This effect was most likely caused by the supplements replacing forage intake. Supplementation tended to lower forage DMD compared to a non-supplemented forage diet, however total DMD was not different between non-supplemented and supplemented treatments. Villalobos et al. (1997) observed no difference in range herbage intake and total intake between cows grazing range or supplemented with hay, soybean:wheat, and soybean meal:hay. The DMD of range herbage was greater for non-supplemented than for supplemented treatments. Willms et al. (1998) using a canola-based protein supplement concluded that forage intake was reduced with increased protein supplementation. However, protein supplementation of 0.4 kg/d did result in higher forage intakes than the non-supplemented treatment. From these examples, it can be observed that supplementation of range diets with protein and energy may be inconsistent. Through the use of supplementation, Willms et al. (1998) concluded that increased numbers of animals or longer time spent grazing could occur.

Animal performance on stockpiled forages can be variable depending on such factors as animal age, experience, weather, forage species, and supplementation. Allen et al. (1992b), utilized weaned calves in a stocker system. Final season weights of stockers grazing N-fertilized tall fescue and tall fescue –legume mixtures were greater than those of similar animals fed hay or tall fescue silage. Weight gains by animals grazing stockpiled tall fescue-red clover or alfalfa were greater than those of animals that grazed N-fertilized tall fescue. Rate of gain was greater during the first 28 d and during the entire season for stockers grazing tall fescue-alfalfa than stockers grazing tall fescue-red clover. Allen et al. (1992a), reported no differences in body weight or body condition score changes between cows grazing stockpiled tall fescue-red clover, orchardgrass-red clover, or orchardgrass-alfalfa forages. Hitz and Russell (1998) reported that cows grazing stockpiled tall fescue-alfalfa gained 29 kg while cows grazing smooth bromegrass lost 4 kg during the winter with hay supplementation. When red clover was included with the smooth bromegrass, cow body weights were similar to that of tall fescue-alfalfa. Body condition scores of cows followed similar trends as body weight. Kartchner (1981), observed no difference in body weight gains of cows grazing native range or grazing with protein or grain supplements. During a second trial, equal losses of BW occurred in cows grazing with or with protein or grain supplementation. In a 112 d winter grazing study, Villalobos et al. (1997), observed that cows grazing only native range lost 25 kg of BW and 1.2 units of body condition compared to grazing cows receiving supplemental hay, soybean meal:wheat, and soybean meal:hay having body weight gains of 37, 27 and 41 kg and body condition score increases of .1, .1, and 0. Willms et al. (1998), observed body weight and body condition score changes as protein supplementation of gestating cows grazing fescue rangeland increased from 0, .4, .8, and 1.2 kg/d. Body weight losses were 35.1, 46.1, 25.1, and 19.5 kg as protein supplementation increased. Back fat loss also decreased from 1.05 to .94, .56, and .44 mm as protein supplementation increased.

Summer Nutritional Management of Beef Cattle

Summer grazing of cows is generally thought to include the time period from early May to late October. Traditionally animals grazing during this time are in some form of production be it a lactating cow, a growing calf, or growing stocker animal. These grazing animals are, therefore, consuming forages when forages are in productive stages. Many considerations should be addressed during summer grazing of beef cattle. Cattle production during the summer varies by the end-product goal be that weaned calf, heavier stocker animals, or gestating cow. Summer management strategies will vary, however, in two factors that apply to all production systems; forage species that is to be grazed and grazing management.

Forage species

Selection or availability of the forage species to be grazed can have important implications in cattle production systems. In the Midwest, a large variety of species are available for grazing during the summer. Foremost of these forage species would be grasses. Grasses are broadly classified as cool-season or warm-season grasses. Cool-season grasses produce the majority of their growth during spring and early summer, becoming dormant during mid-summer and expressing a variable amount of growth during fall. Several species of cool-season grasses have been reviewed in Heath et al., (1973) including bluegrass, smooth bromegrass, reed canary grass, timothy, orchardgrass and the fescues. The use of nitrogen fertilizer with these grasses improves forage production (Woodhouse and Griffith, 1973; Tucker et al., 1989; Nichols et al., 1990). Application of nitrogen fertilizer has been reported to increase herbage production with application of 63 kg/ha of nitrogen increasing herbage yields by two and half times compared to no nitrogen (Brown and Munsell, 1946).

Anderson et al. (1948) showed linear increases of smooth bromegrass herbage production with linear increases of nitrogen fertilization up to 67 kg/ha. Nichols et al. (1990) reported a quadratic response to nitrogen fertilizer on a smooth bromegrass-dominated native range. Regression analysis predicted herbage yield increases of 1,002, 703, and 402 kg/ha for each additional 45 kg/ha of nitrogen from 0-135 kg/ha. Forage crude protein concentrations were reduced with the application of the first 45 kg/ha nitrogen fertilizer applied. Concentrations of IVDMD decreased .09% with each 45 kg/ha of nitrogen fertilizer applied. Nichols et al. (1990) suggested that the reduction of IVDMD was caused by the increased herbage yield brought about because of stem elongation of the grass. Hoveland and Richardson (1992) examined nitrogen fertilization on herbage yields of tall fescue-birdsfoot trefoil forage. Nitrogen fertilization increased herbage yields, with the greatest effect was observed from a split-season application of 56 kg/ha in both February and September. Sweeney et al. (1996) reported tall fescue herbage masses in early spring were 1,350 kg/ha without nitrogen fertilization compared to 2.350 kg/ha with 168 kg/ha of nitrogen applied one month earlier. Hay yields of tall fescue without nitrogen were 2,080 kg/ha compared to 6,480 kg/ha with 168 kg/ha of nitrogen. Sheaffer et al. (1990), examined grass stands and yields in mixtures with alfalfa. Similar stands of smooth bromegrass, orchardgrass and reedcanary grass were obtained when subjected to two cuttings during the summer. When subjected to three and four summer cuttings, orchardgrass final stands were seven times greater than smooth bromegrass and reed canarygrass final stands. Forage chemical compositions of smooth bromegrass, orchardgrass, reedcanary grass mixtures with alfalfa were similar because of the large amount of alfalfa in these stands. Mean concentrations of crude protein, IVDMD and NDF were 20%, 73%, and 45%. Hall (1998) harvested grass species four times at 35-d intervals using an initial application of 56 kg/ha of nitrogen and subsequent applications of 39.2 kg/ha of nitrogen after each harvest. Dry matter yields, CP concentrations and IVDMD concentrations were 12,000 kg/ha, 17.2% and 67.3% fir orchardgrass; 12,500 kg/ha, 18.3% and 68.6% for reed canarygrass, and 11,000 kg/ha, 19.0% and 69.1% for smooth bromegrass. Peters et al. (1992) measured yield and IVOMD of three grass species in June and August. In June, Kentucky 31 tall fescue had herbage yields of 5,175 kg/ha compared to 3,663 kg/ha from an endophtye-free tall fescue and 3,327 kg/ha from orchardgrass. Concentrations of IVOMD were 68.5, 65.9, and 56% for Kentucky 31, endophtye-free tall fescue, and orchardgrass. In August yields were 2,286, 2,965, and 2,321 kg/ha and IVOMD concentrations were 55, 54, and 51% for Kentucky 31, endophtye-free tall fescue and orchardgrass.

Animal performance was affected by forage species Peters et al., (1992). Cows grazing Kentucky 31 tall fescue, an endophtye-infected variety, lost 42 kg of body weight during the summer grazing season compared to body weight losses of 9 or 13 kg for cows grazing endophtye-free tall fescue or orchardgrass. Rebreeding percentages were 91, 75, and 71% for cows grazing endophtye-free tall fescue, orchardgrass, and Kentucky 31 tall fescue. Calf average daily gain and 205-d weaning weights of calves from cows grazing Kentucky 31 tall fescue were lower than from cows grazing endophtye-free tall fescue or orchardgrass. Tucker et al. (1989) also observed losses of .06 kg/d for cows grazing nitrogen fertilized tall fescue 50% infected with endophtye. Compared to cows grazing smooth bromegrass-red clover or orchardgrass-red clover, which gained .14 kg/d from May to September. Allen et al. (1992a) reported that cows grazing tall fescue-ladino clover during the summer had greater body weights (484 vs. 460 kg) than cows grazing bluegrass-white clover pastures.

There were no difference in percentage of cows pregnant, calf average daily, or weaning weights between tall fescue-ladino clover and bluegrass-white clover grazing systems. Allen et al. (1996), observed that heifer and steers sequentially grazing bluegrass-white clover with orchardgrass-alfalfa gained more body weight than heifer and steers sequentially grazing bluegrass-white clover with tall fescue-red clover. Additionally heifers and steers grazing only nitrogen fertilized tall fescue had lower body weight gains than animals sequentially grazing. Marshall et al. (1998) compared responses of large and medium-frame cattle grazing mixed grass-legume pastures. In two out of three years, large-frame cows lost body compared to medium-frame cows. Both groups of cows lost body fat in two out of three years, however body fat gains were great enough during the third year to produce three-year mean fat increases. Weaning weight and average daily gain were greater for calves from large-frame cows than calves from medium-frame cows.

Legumes fill an important area in beef forage systems. Legumes have the ability to fix atmospheric nitrogen into the soil, which can then be utilized by grass (Rhykerd and Noller, 1973). Allen (1973) stated several reasons why legumes are important as forages. Legumes store large amount of protein in leaves and stems, provide minerals such as P, K, and Ca, utilize air nitrogen that is unavailable to grasses, and increase the number and kinds of soil microorganisms. This ability of legumes to utilize atmospheric nitrogen comes about through a symbiotic relationship of the legume plant and rhizobia bacteria that penetrate the root and form nodules (Allen, 1973).. Several species of legumes have been reviewed in Heath et al. (1973) including alfalfa, red clover, sweet clover, white clover, birdsfoot trefoil, and lespedeza.

Forage quality of several species of legumes have been examined by Marten et al. (1987) using beef heifers. After 28 d of grazing, birdsfoot trefoil IVDMD was 80% compared to 77 and 73% for alfalfa and sainfoin. After 98 d of grazing, birdsfoot trefoil IVDMD had decreased to 66%, alfalfa decreased to 70 and sainfoin to 65% IVDMD. Marten et al. (1990), utilized sheep in a grazing experiment comparing legume quantities and quality. Mean seasonal CP of alfalfa and birdsfoot trefoil was 21.7% and red clover was 20.8% CP. Mean seasonal IVDMD concentrations were 71.4, 73.1, and 78.3% for alfalfa, birdsfoot trefoil, and red clover. Collins (1982), studying stockpiled birdsfoot trefoil, observed yields of 3.26 metric tons/ha in late May, 5.94 metric tons/ha in mid July, and 2.06 metric tons/ha in mid October. Crude protein concentrations were 18.1 18.8 and 17.8% in late May mid-July, and mid-October. Concentration of IVOMD decreased from 81.6 % in late-May to 68.6% in mid-July but then increased to 71.0% in mid-October. Russell et al. (1993b), observed greater initial dry matter yield of smooth bromegrass-orchardgrass pastures with the inclusion of birdsfoot trefoil. In the second year of the experiment when nitrogen was applied to smooth bromegrass-orchardgrass pasture, herbage yields were similar between fertilized pastures and those that contained birdsfoot trefoil. Beck and Russell (1991) compared forage production of alfalfa-grass to smooth bromegrass with 45 kg /ha of nitrogen. Initial and monthly dry matter yields were not different between the two forage systems. Yields and quality of grass-legume mixture results by Tucker et al. (1989), Sheaffer et al. (1990), Hoveland and Richardson (1992), Allen et al. (1996), and Marshall et al. (1998) have been previously discussed in the grass section.

Marten et al. (1987) observed that heifers grazing birdsfoot trefoil or sainfoin gained more body weight than heifers grazing alfalfa forages over 98 d. Marten et al. (1990)

observed that mean average daily gains of sheep were,.22 kg/d and did not differ for lambs grazing alfalfa, birdsfoot trefoil or red clover. Lamb product gain kg/ha was greater 784 kg/ha for alfalfa, compared to 744 and 739 kg/ha for lambs grazing birdsfoot trefoil or red clover forages. The greater IVDMD that occurred in red clover forages compared to alfalfa and birdsfoot trefoil was not accompanied by increased in lamb weight gains. Beck et al. (1991) observed 18 kg greater body weight gains and .13 unitincreases of body condition score of cows grazing mixed grass-alfalfa pastures compared to nitrogen fertilized smooth bromegrass across stocking rates and system. Adjusted 205-d weaning weights were 18 kg greater, calf gains were 73 kg/ha greater, and total beef produced was 20 kg/ha greater from mixed grass-alfalfa pastures than nitrogen-fertilized pastures. Russell et al. (1993b) observed that cows grazing smooth bromegrass-orchardgrass-birdsfoot trefoil pastures gained 46 kg compared to 33 kg from cows grazing nitrogen-fertilized smooth bromegrass-orchardgrass pastures during the summer. Calf average daily gains and total calf produced between the forage systems were similar at 1.21 kg/d and, 101 kg/ha. Other results from cow-calf and stockers grazing mixed grass-legume forages have been discussed previously (Tucker et al., 1989; Allen et al., 1996; Marshall et al., 1998).

Grazing management

The two most powerful tools producers have for influencing the level of animal output under grazing are: 1) the system of grazing management and 2) the concentration of animals per unit of area (stocking density; Matches and Burns, 1995). An adequate review of stocking systems and density can be found in Matches and Burns (1995). It should be noted that the bulk of research regarding stocking systems has focused on differences between continuous and rotationally stocked pastures. But differences in stocking densities are included in much of this research.

Continuous stocking is the continuous, unrestricted grazing of a specific range or pasture by livestock throughout a year or grazing season (Forage and Grazing Terminology Committee, 1992). Rotational stocking is the grazing of two or more paddocks in sequence followed by a rest period for recovery and regrowth of the grazed herbage (Forage and Grazing Terminology Committee, 1992).

Hart et al. (1993) examined the differences between continuous and rotational stocking on western wheatgrass and blue grama. No difference occurred in the mass of peak standing crop between the continuous and rotational stocking systems. Stocking systems also had no influence on the percentage of tillers grazed multiple times or the percentage of biomass removed. Taylor et al. (1993), however, did observe that botanical composition shifted with either the use of short duration (rotational) or high intensity low-frequency (continuous) stocking. Popp et al. (1997b) utilized both continuous and rotational stocking at light and heavy stocking densities. Grazing season length was greater for rotational than continuous stocking systems. Forage production and botanical composition was not different between rotational and continually stocked pastures. Carrying capacity (steer d/ha) was greater for the heavy-rotationally stocked pastures than low or high stocked continuous pastures. Average daily gain of steers stocked continuously was 1.24 kg/d compared to 1.19kg/d for steers rotationally stocked on pastures. Total live weight gain was also similar, (153 kg and 160 kg) for continuously and rotationally stocked steers. Hoveland et al. (1997) examined continuous and rotational stocking using tall fescue-bermudagrass mixtures, and found that average total available forage was greater for rotationally stocked pastures than continuously pastures. There was however, no difference in concentrations of CP or IVOMD between rotational and continuously stocked pastures. Rotationally and continuously stocked pastures resulted in no difference in cow weight, pregnancy rate and calf weaning weight. Calf production was greater for rotational stocking (367 kg/ha) compared to continuously stocked (272 kg/ha) pastures. This result was caused by rotationally stocked pastures being stocked at higher densities. Hay feeding was reduced by 341 kg/cow for cows rotationally stocked rather than continuously stocked. Bertelsen et al. (1993) compared continuously stocked tall fescue-orchardgrass-alfalfa pastures to rotationally stocked 6 and 11 paddock tall fescue-orchardgrass-alfalfa pastures grazed by heifers. Heifer average daily gain and organic matter intakes were similar among all three treatments. Forage quality measurements of IVOMD, NDF, ADF, and CP were all similar between stocking systems. Heifer body weight gains/ha were 40 and 34% greater on the 6-paddock and 11-paddock rotational stocked than the continuously stocked system. Rotational stocked systems increased beef production/ha caused by higher stocking densities that were utilized. Russell et al. (1993b) compared continuously smooth bromegrass-orchardgrass with or without birdsfoot trefoil stocked pastures at 1.23 cow-calf pairs/ha to rotationally stocked smooth bromegrass-orchardgrass with or without birdsfoot trefoil stocked pastures at 1.73 cow-calf pairs/ha. Initial forage yields were 400 kg/ha greater for rotationally stocked pastures than continuously stocked pastures. Cow seasonal body weight gains were 41 and 31 kg for continuously and rotational stocked pastures. Calf average daily gains were 1.25 and 1.18 kg/d for continuously and rotational stocked pastures. Because of the increased stocking density, rotationally stocked pastures produced 70 kg/ha more calf than continuously stocked pastures. Beck and Russell (1991) observed similar cow seasonal body weight changes, body condition scores, 205-d calf weaning weights and calf average daily gain between continuously stocked smooth bromegrass or alfalfa-grass pastures and high intensity rotational stocked smooth bromegrass or alfalfa-grass pastures. However calf seasonal gain was greater for rotationally stocked pastures (351 kg/ha) than continuously stocked pastures (364 kg/ha).

Differences between stocking densities were examined by Bryan et al., (1994). Pastures were stocked at 3, 4, or 5 steers/ha grazing Kentucky bluegrass-white clover pastures. Herbage yields were greater for pastures stocked at 3 steers/ha than 4 or 5 steers/ha. Crude protein concentrations were lower and NDF and ADF concentrations higher from pastures stocked at 3 steers/ha than 4 and 5 steers/ha. Steer average daily gain was .81 kg/d for 4 steers/ha compared with .73 kg/d for 3 steers/ha and .62 kg/d for 5 steers/ha. Like average daily gain, gain/ha was greater from 4 steers/ha than 5 steers/ha or 3 steers/ha. Beck and Russell (1991) examined high and low stocking density on mixed grass-alfalfa rotational stocked pastures. Both total available herbage and sward heights were greater on low density stocked pastures than high density throughout the entire grazing season. Cow body weight gain, and body condition score change were greater for cows grazing at the low stocking density than the high stocking density. Calf average daily gains were not different between the two stocking densities, but calf gain/ha were greater for the high stocking density system (438 kg/ha) compared to low stocking density system (259 kg/ha). Fales et al. (1995) utilized dairy cows grazing orchardgrass-bluegrass pastures at three stocking densities. In the spring, herbage DM yields were 300 and 690 kg/ha greater on the low stocking than the moderate and greater stocking density. During the grazing season, concentrations of CP, NDF and IVDMD were not different for forages from the three stocking densities. Marten and Jordan (1972) compared put-take and fixed stocking systems at three stocking densities.

Average daily gain were greatest for lambs grazing at the low density-fixed stocking system whereas lowest daily gains were observed on a heavy density,put-and-take system. However, lamb gains/ha were greatest on the heavy density-put-and-take system and lowest on the low density-put-and-take stocking system. Tallowin et al. (1986) initially stocked pastures at three densities to attain three sward heights. During the phase to attain the target sward heights, herbage masses differed by 1000 kg OM/ha between the high and low stocking densities. Grazing days/ha was lower for the low and moderate stocking densities than for the high density stocking system. Cattle body weight gains and live weight gain/ha were not different between the three stocking densities. Popp et al. (1997b) stocked steers at 1.1/ha (low) and 2.2/ha high. In the low density stocking system, grazing time was reduced but intake was increased over the heavy stocking density. This result may be due to the low density stocking system having greater seasonal herbage mass. Steer average daily gain and total live weight gains were greater for the low than the heavy density stocking system. Hart (1978) reviewed the basic relationships between stocking density and individual animal performance. At low stocking densities, individual animal performance is maximized but production/unit area of land will be decreased. As stocking densities increase, gains /animal decrease while gains/land unit increase to a point beyond which increasing stocking densities reduces both gain/animal and gain/land unit.

In grazing management systems, the goal is to utilize forage in a manner that maintains quality while at the same time leaving enough forage residues for latter grazing. This goal is not always attainable and the production of forage outpaces the animals abilities to utilize the available forage. In these cases, alternative methods of forage control must be implemented. These control measures fall into two broad categories, mechanical harvest and adjustment of stocking density (Jacobs, 1973). Fales et al. (1995) stated that areas rejected by grazing animals during rapid growth in the spring would impair summer production because cows will not consume the rejected forage. If herbage is rejected or unutilized in one cycle of grazing, that forage will not be consumed by cows during subsequent cycles and amounts to wasted forage dry matter. When stocking density or pressure is too low, significant amounts of forage can go unutilized. Mechanical harvest allows for timely removal of excess forage. Mechanical harvest does increase the input costs to forage production because of the use of heavy equipment. Mechanical harvest does, however, produce stored forages that can be utilized for winter or sold. Fales et al. (1995) utilized excess spring forage in a dairy cow grazing experiment by harvesting silage. Silage harvested amounted to 2,400 kg/ha, but yields on a per cow basis were different between low and moderate stocking densities. Bertelsen et al. (1993) removed excess forage in rotationally stocked pastures hay. Selected paddocks were mowed and baled during the first week of grazing to prevent forage from becoming to mature. Hay yields were 1,225 kg DM/ha. Marten and Jordan (1972) also utilized pasture clipping to maintain a sward height of 5 cm. These authors found that clipping removed dead stubble and inflorescence, which prevented senescent material from reducing pasture quality.

Adjusting the stocking rate is another method of controlling forage quantity and quality. Adjusting the stocking density or pressure after the start of the grazing season implies that animals must be added or removed. Marten and Jordan (1972) defined put-and–take stocking as the use of variable animal stocking densities during the grazing season to adjust animal numbers periodically according to the carrying capacity of the pasture. In application animals are placed onto pastures with animals under examination in order to maintain sward height or herbage masses within desired ranges. In cow grazing experiments, Hoveland et al. (1997) observed that rotational stocking provided more forage than could be utilized. Therefore, additional cows were utilized from April to November to maintain similar grazing pressures between treatments. Bertelsen et al. (1993) utilized additional heifers in a put-and-take system to maintain the experimental forage density of 8 to 15 cm and herbage yields of 1,200 to 1,600 DM kg/ha. Marsh (1979) utilized increasing the forage allowance/100 kg animal weight to control early spring forage. Dry matter disappearance of forages from pastures and proportion of forage utilization increased as forage allowance decreased implying that by increasing the weight or number of animals grazing, more forage was removed. Higher digestibility of forages was maintained during the mid-grazing season on pastures that had been subjected to low forage allowance. Popp et al. (1997a) observed much the same effects. Steers stocked at 1.1/ha consumed 11.32 kg OM/d, which amounted to 12.45 kg OM/d/ha compared to steers stocked at 2.2/h that consumed 10.4 kg OM/d amounting to 22.88 kg OM/d/ha. Tallowin et al. (1996) utilized three initial grazing pressures. In June, all pastures were grazed at a common moderate pressure and herbage masses were adjusted by put-and take method. In June, IVOMD on offer and total herbage selected by cattle was greater for pastures that had severe grazing pressure compared to light grazing pressure. This difference came about by a higher proportion of young digestible leaf, less dead material, and less mature stems. Heitschmidt et al. (1990) utilized another approach by increasing animal rotation among paddocks during rapid forage growth. Increasing rotation frequency on paddocks would therefore also increase animal days/ha.

Uses of Grazing in Growing and Finishing Beef Cattle

Lawrence and Pearce (1964) have extensively reviewed the use of grazing for the production of beef cattle. Those authors addressed topics of forage quality and quantity, growth rate, compensatory gains, and carcass characteristics and body composition. Allen et al. (1992, 1996) have examined the use of forages for production of beef cattle.

Previous nutrition of growing cattle during one phase will influence production during another. Heinemann and Van Keuren (1956), Meyer et al. (1965), and Horton and Holmes (1978) have reported compensatory gains in body weight of cattle grazing. Lawrence and Pearce (1964) wintered calves on high, medium, and low planes of nutrition for 168 d to achieve daily gains of .73, .34, and .01 kg/d. Cattle were then grazed together on grass for 140 d during the summer. The medium and particularly the low treatment groups gained more body weight (138 and 168 kg) than the high treatment (79 kg). Average daily gains during grazing were .57, .98, and 1.2 kg/d for high, medium and low treatments. These different rates of gain between treatment groups reduced the disparity that had occurred caused by winter treatment. A complete reduction in the difference between high and low treatments did not occur. However, a negative correlation between winter gain and summer gain was apparent. Lewis et al. (1990) fed calves to gain .28, .38, or .50 kg/d for 106 d during the winter. Calves then sequentially grazed nitrogen-fertilized smooth bromegrass followed by warm season grasses. A linear decrease in pasture body weight gain was observed as winter body weight gain increased. Lewis et al. (1990) determined that for each 100g of winter gain, pasture gain was reduced by 81g because of less compensatory gain. At the end of summer grazing, winter and pasture gains were equal for the three treatments. White et al. (1987) observed similar a similar response in that winter gains were inverse to gains that occurred during summer grazing gains. Baker et al. (1992) determined that differing wintering diets in the amount of energy to protein had effects on body composition and empty body weight. These differences in body composition were compensated for during the summer grazing period. Cattle that were fed silage retained more fat during the winter, but during summer grazing more protein and less fat was deposited. Cattle that were fed restricted diets during the winter gained more body weight during the summer than cattle were fed ad libitum during the winter. Cattle fed ad libitum levels during the winter had lower body weight, body weight gain/d and energy retention than those fed restricted levels or silage during summer grazing. Allen et al. (1992b) utilized fall-weaned calves to grazed stockpiled forages compared to conserved forages for stocker management systems. Systems utilized included grazing stockpiled nitrogen-fertilized tall fescue, tall fescue-red clover, and tall fescue-alfalfa, or feeding of tall fescue hay, orchardgrass-alfalfa hay, and tall fescue silage. Daily gains were greater for heifers and steers grazing stockpiled tall fescue-alfalfa (.5 kg/d) than tall fescue-red clover or tall fescue (.33 and .34 kg/d). However, the number of days supplemental hay was fed was greater for tall fescue-alfalfa (105 d) compared to 60 d for tall fescue-red clover and 36 d for tall fescue. Daily gains were similar for animals grazing stockpiled tall fescue-alfalfa and fed orchardgrass-alfalfa hay, which was considered high quality. Tucker et al. (1989) observed steers that were continuously stocked on smooth bromegrass-red clover or orchardgrass-red clover had similar body weight gains (.84 kg/d) and both were greater than steers stocked on nitrogen-fertilized tall fescue (.70 kg/d). The greatest body weight gains occurred during May, while the lowest gains occurred in September, which was most likely caused by reduced forage availability at the end of the grazing season and steer maturity. In July, steers stocked on nitrogen-fertilized tall fescue pastures had reached 91% of the total season gain, which would indicate that these animals should be removed or supplemented to continue adequate body weight gains. By comparison, steers stocked on smooth bromegrass-red clover or orchardgrass-red clover reached 98 and 96% of final weight in August. Marsh (1979) observed that as forage allowance (kg DM/100 kg BW) increased linearly from 3.0 to 7.5, daily body weight gains and final body weight increased linearly also. Maximal daily body weight gains between two experiments occurred at a forage allowance of 7.5, which resulted in gains of .63 kg/d. Elizalde et al. (1998) grazed growing cattle on endophyte-infected tall fescue with supplementation of cracked corn or corn gluten feed at 1.4 or 2.8 kg/d or cornstarch and corn gluten feed at 1.4 kg/d. Supplemented animals had greater daily body weight gains, (.74 kg/d) than nonsupplemented animals, (.64 kg/d).

Allen et al. (1996) utilized the same animals as in the stocker experiments. Animals from the stocker systems were assigned to one of three finishing systems 1) nitrogen fertilized tall fescue, 2) bluegrass-white clover followed by tall fescue-red clover, 3) bluegrass-white clover followed by orchardgrass-alfalfa. Heifers and one-half of the steers were supplemented with 1% BW/d corn grain, and the nonsupplemented steers were fed corn silage in a feedlot for two months after grazing. Cattle that grazed orchardgrass-alfalfa forage during the finishing phase had greater body weight gains and better carcass characteristics than cattle that grazed tall fescue-red clover or nitrogen-fertilized tall fescue. Type of forage received during the stocker phase affected performance and carcass characteristics. Tall fescue as hay or silage resulted in reduced body weight gains during the feedlot phase that was not alleviated by feeding a high concentrate at the end of the finishing period. Lewis et al. (1990) observed that wintering treatment and summer gains had no effect on days spent in feedlot, daily gain, feed use, or gain-to-feed ratio. Carcass characteristics were similar among animals regardless of winter treatment or summer gain. Mean hot carcass weights were 330 kg; fat depth, 1.16 cm; yield grade, 2.76; and quality grades were average choice. White et al. (1987) compared animals that were sent directly to the feedlot and those that grazed during the summer after differing winter treatments then placed into a feedlot. Animals that grazed during the summer spent less time in the feedlot, however, they had lower carcass weights, quality grades, marbling scores and reduced fat thickness. Differing winter treatments had little influence on carcass characteristics. Animals from winter treatments that lost body weight spent more days in the feedlot than those animals that gained winter body weight. Carcass weights and quality grades were similar between winter treatments, but marbling score and fat thickness were variable among winter treatments. Marsh (1979) observed that increased final carcass had a linear relationship with increasing forage allowance. There was no difference in carcass weight daily gain (.54 kg/d) between forage allowances. Fat-free gain was 80 and 81 g/d for forage allowances of 3.0 and 4.5 kg forage DM/100 kg BW, whereas, steers provided forage allowances of 6.0 and 7.5 kg forage DM/100 kg BW had fat free gains of 42 and 46 g/d. Elizalde et al. (1998) reported that supplementation during grazing did not affect finishing average daily gain or body weight. Combining grazing and finishing period, daily gains were not different between supplemented and unsupplemented animals. Supplementation had little affect on carcass characteristics, however longissimus was larger, dressing percentage greater, and hot carcass weights tended to be greater for supplemented than unsupplemented animals.

EVALUATION OF YEAR-ROUND FORAGE MANAGEMENT SYSTEMS FOR BEEF COW-CALF PRODUCTION:

I. WINTER SYSTEMS[1]

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ABSTRACT

A 3-yr experiment was conducted to compare BW and condition score changes and stored hay feeding of beef cows that sequentially stocked corn crop residues and stockpiled endophyte-free tall fescue-red clover or smooth bromegrass-red clover forages to cows maintained in a drylot as the winter portion of a year-round forage management project. Crossbred cows in midgestation were allotted to three treatments: 1) sequential stocking of corn crop residues at .61 ha/cow and stockpiled tall fescue-red clover at 1.21 ha/cow; 2) sequential stocking of corn crop residues at .61 ha/cow and stockpiled smooth bromegrass-red clover at 1.21 ha/cow; or 3) drylot feeding of hay harvested from .25 to .51 ha/cow of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures. All cows were offered hay to maintain a condition score of five on a 9-point scale. Body weights and condition scores of cows sequentially stocked on corn crop residues and stockpiled forages decreased more ($P <$ .05) than cows maintained in a drylot during corn crop residue grazing from October through December. While grazing stockpiled forages from February through April, cows lost less (P $< .05$) BW and gained more ($P < .05$) body condition score than cows maintained in a drylot. Seasonal BW and condition score changes did not differ between cows in the different management systems. Amounts of hay fed ($P < .05$) and amounts of hay harvested in excess of that fed ($P < .05$) were 155, 3,116; 199, 3,347; and 2,869, -1,611 kg DM/cow for cows sequentially stocked on corn crop residues and stockpiled tall fescue-red clover, sequentially stocked on corn crop residues and stockpiled smooth bromegrass-red clover, or maintained in a drylot. Organic matter masses of corn crop residue, tall fescue-red clover, and smooth bromegrass-red clover forages were 3,686, 2,609 and 2,313 kg/ha at the initiation of corn

crop residue grazing ($P < .05$) and decreased at 29.9, 7.5; 10.1, 3.7; and 7.3, 3.5 $kg.ha^{-1}.d^{-1}$ from grazed and ungrazed areas over 139 d (species, $P < .01$). Concentrations of in vitro OM disappearance corn crop residue, tall fescue-red clover, and smooth bromegrass-red clover forages decreased ($P < .01$) at .11; .12; and .04% unit/d, over 139 d. Grazing cows required less stored feed during winter to maintain similar BW and condition scores as cows maintained in a drylot.

Key Words: Beef Cows, Winter, Grazing, Corn Crop Residues, Stockpiled Forage

Introduction

Extending the grazing season into winter reduces feed costs required for maintaining pregnant beef cows and may improve the profitability of beef cow-calf production in the upper Midwest (D'Sousa et al., 1990; Strohbehn, 1990; Adams et al., 1984). Grazing of corn crop residues has been utilized for production of beef calves (Klopfenstein et al., 1987) and maintenance of beef cows in midgestation (Ward, 1978; Russell et al., 1993). Because of large weathering losses of digestible OM, however, the value of corn crop residues for late winter grazing is limited (Gutierrez-Ornelas and Klopfenstein, 1991; Russell et al., 1993). Grazing of stockpiled perennial cool-season forages has reduced the amounts of hay required for cows during winter (Allen et al., 1992; Hitz and Russell, 1998). Although the rates of decrease of in vitro OM disappearance (IVOMD) did not differ between corn crop residues and stockpiled grass-legume forages, higher initial IVOMD concentrations of stockpiled grass-legume forages result in these forages having higher IVOMD concentrations than corn crop residues in late winter (Hitz and Russell, 1998). Thus, on enterprises that have both corn crop residues and stockpiled grass-legume forages as resources for winter grazing, most effective utilization should be achieved by grazing corn crop residues in late fall and early winter when the nutrient requirements of spring-calving cows are low (NRC, 1996) and grazing stockpiled forages in late winter when the nutrient requirements of spring-calving cows increase (NRC, 1996). Because mass and nutritive value of stockpiled forages is affected by forage species (Archer and Decker, 1977; Hitz and Russell, 1998) and nitrogen fertilization (Archer and Decker, 1977), the efficacy of stockpiled forage for late winter grazing likely is affected by these factors.

The objectives of the present experiment were to compare the forage mass and nutritive value of corn crop residues and stockpiled tall fescue-red clover or smooth bromegrass-red clover forages throughout the winter and to compare the performance of beef cows grazing corn crop residues and stockpiled forages in sequence to those maintained in a drylot during winter.

Materials and Methods

Pastures

A 3-yr grazing management experiment was conducted on four 6.07-ha pastures and four 3.04-ha corn crop residue fields at the McNay Research and Demonstration Farm near Chariton, IA. Soil in these areas was primarily Grundy silty clay loam with 2 to 7% slopes. In 1990, endophyte-free tall fescue (*Festuca arundinacea* var. Johnstone) and alfalfa (*Medicago sativa* var. Spredor II) were seeded into two 6.07-ha pastures. In 1992 through 1995, first and second cutting forages from the two tall fescue-alfalfa pastures and two 6.07-ha pastures containing a perennial stand of smooth bromegrass (*Bromus inermis* L.) were harvested as hay in large round bales. In 1992 through 1994, third cutting forage was stockpiled from early August to late October and grazed for approximately 140 d (Hitz and

Russell, 1998). Because the smooth bromegrass pastures had no legume species and the proportion of alfalfa in the tall fescue-alfalfa pastures decreased considerably after 1993, red clover (*Trifolium pratense* var. Arlington) was broadcast-seeded at 9 kg/ha into the smooth bromegrass and tall fescue-alfalfa pastures in early March of 1993 and 1994, respectively. In order to maintain red clover stand, red clover was broadcast-seeded into each pasture at 4.5 kg/ha in late February of each subsequent year through 1998. In 1995 (yr 1), third growth tall fescue-red clover and smooth bromegrass-red clover forages were allowed to stockpile from August 6 until a killing frost. In the summer of 1996 (yr 2) and 1997 (yr 3), one cutting of hay of each forage mixture was harvested from 4.55 ha on July 1 and 6.07 ha on June 17 from each pasture, respectively. As discussed in a companion paper (Hersom et al., 2000), five cow-calf pairs and one bull grazing as part of the summer component of the year-round grazing systems grazed first growth forage from the remaining 1.52 ha of each forage mixture in yr 2 and second growth forage from the entire area of each pasture until stockpiling was initiated on August 7 (yr 2) and 5 (yr 3). In yr 2 and 3, tall fescue-red clover and smooth bromegrass-red clover pastures were fertilized with ammonium nitrate at 44.8 kg N/ha at the initiation of stockpiling. Following corn grain harvest in October of each year, each corn field was divided into four .76-ha paddocks, and each stockpiled forage pasture was divided into four 1.52-ha paddocks to be strip-grazed as the winter portion of the year-round grazing system.

For comparison to a system in which hay harvested from summer pastures was fed to cows maintained in a drylot during winter, first cutting hay was harvested as large round bales from 1.01, 1.52, and 2.02 ha of four 4.04-ha pastures containing smooth bromegrass (*Bromus inermis* L. var. Barton), orchardgrass (*Dactylis glomerata* L. var. Napier), and birdsfoot trefoil (*Lotus corniculatus* L. Norcen) in yr 1, 2, and 3. All bales were stored outside on the ground.

Animal Management

In each year, 36 mature, medium-frame Simmental x Angus x Jersey beef cows (mean BW, 527 kg; mean body condition score, 5.3) in midgestation were blocked by BW and condition score and allotted to three replicated winter systems: 1) sequential stocking of corn crop residues (.61 ha/cow) and stockpiled tall fescue-red clover forage (1.21 ha/cow); 2) sequential stocking of corn crop residues (.61 ha/cow) and stockpiled smooth bromegrass-red clover forage (1.21 ha/cow); and 3) maintenance in a .12-ha dirt drylot (.015 ha/cow) that was doubled in size during the calving season. Strip-grazing of corn crop residues was initiated on October 26, October 31, and October 29 and continued for 57, 57, and 63 d in yr 1, 2, and 3 with a new paddock offered biweekly. After grazing corn crop residues, each group of cows in the sequential stocking treatments was moved to either stockpiled tall fescue-red clover or smooth bromegrass-red clover pastures to strip-graze for 131, 132, and 119 d in yr 1, 2, and 3 with a new paddock offered monthly. Hay harvested during the previous summers was offered to all cows to maintain a body condition score of five on a 9-point scale (Neumann and Lusby, 1986), or when forage availability was limited by weather conditions. All cows were weighed unshrunk at the initiation of corn crop residue grazing, at the initiation of stockpiled forage grazing, prior to calving, and at the termination of winter grazing in May. Cow body condition score was assessed by a single individual biweekly by visual scoring on a 9-point scale. Mean calving dates were April 4, April 12, and April 24 for yr 1, 2, and 3 respectively.

Forage Sample Collection

To determine herbage mass and chemical composition, corn crop residue, tall fescue-red clover, and smooth bromegrass-red clover forages were collected monthly during the grazing experiment. Corn crop residue samples were hand-collected from one randomly selected 4-m^2 area from each grazed and ungrazed paddock within each corn crop residue field to provide a sample collected from a minimum of two ungrazed and two grazed sites in each field per month. After termination of corn crop residue grazing, samples of ungrazed corn crop residues were collected from one 4-m^2 area from each of two 6 x 4-m exclosures within each corn crop residue field. All corn crop residue samples were weighed, ground with a hammer mill to pass through a 2.5-cm screen, and subsampled for further analysis. Stockpiled forages were sampled monthly by hand-clipping three .25-m^2 areas per grazed and ungrazed paddock during the grazing experiment and from one .25-m^2 area within one 1 x 1-m exclosure per paddock (four samples per pasture) at grazing termination. To determine the botanical composition of the tall fescue-red clover and smooth bromegrass-red clover pastures, samples were hand-clipped from twelve .25-m^2 locations in each pasture in late May and September of each year. Samples were hand-sorted into dead forage and green grass, legume and broadleaf weed species, dried at 65°C for 48 h, and weighed.

To determine hay yield and feeding, every large bale was weighed at harvest and feeding. At harvest, six bales from each pasture were randomly selected and core-sampled in two locations on opposite sides of the bale. To estimate hay nutrient weathering losses in November and March, three of these bales were weighed and core-sampled at two depths (from 0 to 23 cm and from 23 to 76 cm) in four locations around the bale (Brasche and Russell, 1988). To determine the DM concentration of hay fed, bales were sampled by the above procedure in November, December, and March in yr 1 and monthly during the grazing experiment in yr 2 and 3. Hay balance was calculated as the amount of hay harvested in each system, adjusted to a per cow basis, minus the amount of hay fed per cow (Hitz and Russell, 1998).

Animal Forage Selection and Intake

To compare the composition of forage selected while grazing corn crop residues in November and stockpiled forages in March to that of cows fed hay, one of six ruminally fistulated steers was allotted to each pasture or drylot. After steers were adapted to the forage for a minimum of 7 d, ruminal contents of steers were evacuated and placed in covered 120-L drums (Russell et al., 1993). Steers were allowed to graze for 2 h. All forage consumed by the steers was collected, mixed, subsampled, and frozen for later analysis. Ruminal contents were returned to the rumen daily after sampling. Grazing selection indices for each chemical component analyzed were calculated as the ratio of the concentration of each component in the selected forage to its concentration in the available forage collected from four 4-m^2 areas of each corn crop residue field, nine .25-m^2 areas of each stockpiled forage pasture before grazing, or by core sampling bales before feeding in each drylot (Hitz and Russell, 1998). Forage selection was measured on two consecutive days in each year except for the cornstalks and hay in November in yr 2 when poor weather allowed only one measurement.

Simultaneous to the determination of forage selection, intake of each forage by cows was estimated from the passage kinetics of chromium-mordanted fiber. Two cows in each field, pasture, or drylot were pulse-dosed with 30 g of chromium-mordanted fiber (1.99% Cr). Fecal samples were collected for 120 h, dried, and ground to pass through the 1-mm screen of a Wiley mill. Chromium concentrations of the samples were determined by the method of Williams et al. (1962) using an air-plus-acetylene flame in an atomic absorption spectrophotometer. Particulate passage kinetics were determined by nonlinear regression (SAS, 1990) of a gamma-two, age-dependent, two-compartment model of fecal chromium concentration (Pond et al., 1988) and used to estimate fecal output (Mann et al., 1987). Fecal samples from each cow, composited on an equal weight basis, and forage samples, selected by fistulated steers, were analyzed for indigestible ADF (Hitz, 1996). Dry matter digestibility (DMD) was calculated as:

$DMD = 1 - (\%IADF_{selected}/\%IADF_{fecal})$. Forage DMI was calculated as:

$DMI = \text{fecal output}/(1 - DMD)$.

Chemical Analyses

Dry matter concentrations of hand-collected corn crop residue and stockpiled forages and core-sampled hay were determined by drying at 65°C for 48 h in a forced-air oven. Samples of forage selected by fistulated steers during grazing were lyophilized. All forage samples were ground with a Wiley mill to pass through a 1-mm screen. Organic matter concentration of forage samples was determined by combustion in a muffle furnace for 2 h at 600°C (AOAC, 1990). In vitro DM disappearance of all forage samples was determined by the procedure of Tilley and Terry (1963), as modified by Marten and Barnes (1980) with filtration on filter paper. Inoculum for IVDMD determination was obtained from a ruminally fistulated steer fed alfalfa and strained through four layers of cheesecloth. To correct for soil contamination of samples, in vitro OM disappearance (IVOMD) was determined as the weight loss from the combustion of filter papers and undigested residue in a muffle furnace at 600°C for 2 h corrected for the weight of the filter paper, expressed as a proportion of the total OM. Forage samples were analyzed for Kjeldahl N, using a selenium catalyst (AOAC, 1990), NDF (Van Soest and Robertson, 1979), ADF (Goering and Van Soest, 1970), and ADIN (Goering and Van Soest, 1970). To correct for soil contamination, NDF, ADF, and CP concentrations were reported on an OM basis.

Statistical Analyses

Initial herbage masses and chemical compositions of corn crop residue and stockpiled forages were analyzed with the GLM procedure of SAS (1988) in a split-plot design with year as a split plot of the main plot of forage species. Mean daily changes in herbage mass and chemical composition were analyzed by linear regression analysis (SAS, 1988) of forage samples from grazed and ungrazed areas of each corn crop residue field and stockpiled forage pasture taken monthly. Regressions for the changes in composition of both grazed and ungrazed corn crop residue and stockpiled forage began at the initiation of corn crop residue grazing each year. Difference in the slopes of the daily changes in herbage mass and chemical composition of forages from grazed or nongrazed areas were analyzed by the GLM procedure (SAS, 1988) as a split-plot design with main effects of year, species, and grazing and two- and three-way interactions of year, species, and grazing. Significance of species effects was tested against the year by species interaction. Differences in the rates of change between species for variables with significant species effects were compared using t-test with significance declared at $P < .05$. Cow BW and body condition score at the initiation of corn crop residue grazing, stockpile forage grazing, calving, and summer grazing and the amounts of hay fed and hay balance were analyzed by ANOVA (SAS, 1988) for a randomized design with main effects of year and system and the two-way interaction of year and system. The significance of differences between means of variables with significant forage species effects was determined using t-tests. Forage selection indices and forage intake were analyzed for each date using the GLM procedure (SAS, 1988) as a split-plot design with main effects of year and forage species and two-way interaction of year and species. Botanical composition of the stockpiled pastures was analyzed with GLM (SAS, 1988) as a split-plot design with a model including the main effects of forage species, season, and year and interactions of species by season, species by year, season by year, and the three-way interaction of species, season, and year. Significance of species effects was tested against the species by season interaction.

Results

Weather

Mean monthly temperatures were equal or slightly below the 46-yr average (1951-1997) during the winter grazing season in yr 1 and 2 (Figure 1; NOAA, 1995; NOAA, 1996; NOAA, 1997; NOAA, 1998). In yr 3, mean monthly temperatures were above average during January and February, then fell below average for the remainder of the winter grazing season. In all 3 yr, monthly precipitation was below the 46-yr average in August and September when most growth of the stockpiled forages should have occurred (Figure 2). During winter grazing, monthly precipitation amounts in yr 1 and 2 were below the 46-year mean except for January of yr 1 and February of yr 2. During yr 3, November was the only month during winter grazing that did not receive an equal or greater amount of precipitation than the 46-yr mean. Snowfall in January of yr 1 amounted to 58.4 cm (Table 1), resulting in 23 d of that month having snow cover of equal or greater than 2.54 cm. In yr 2, snowfall in February amounted to 38.4 cm with 22 d having snow cover of equal or greater than 2.54 cm.

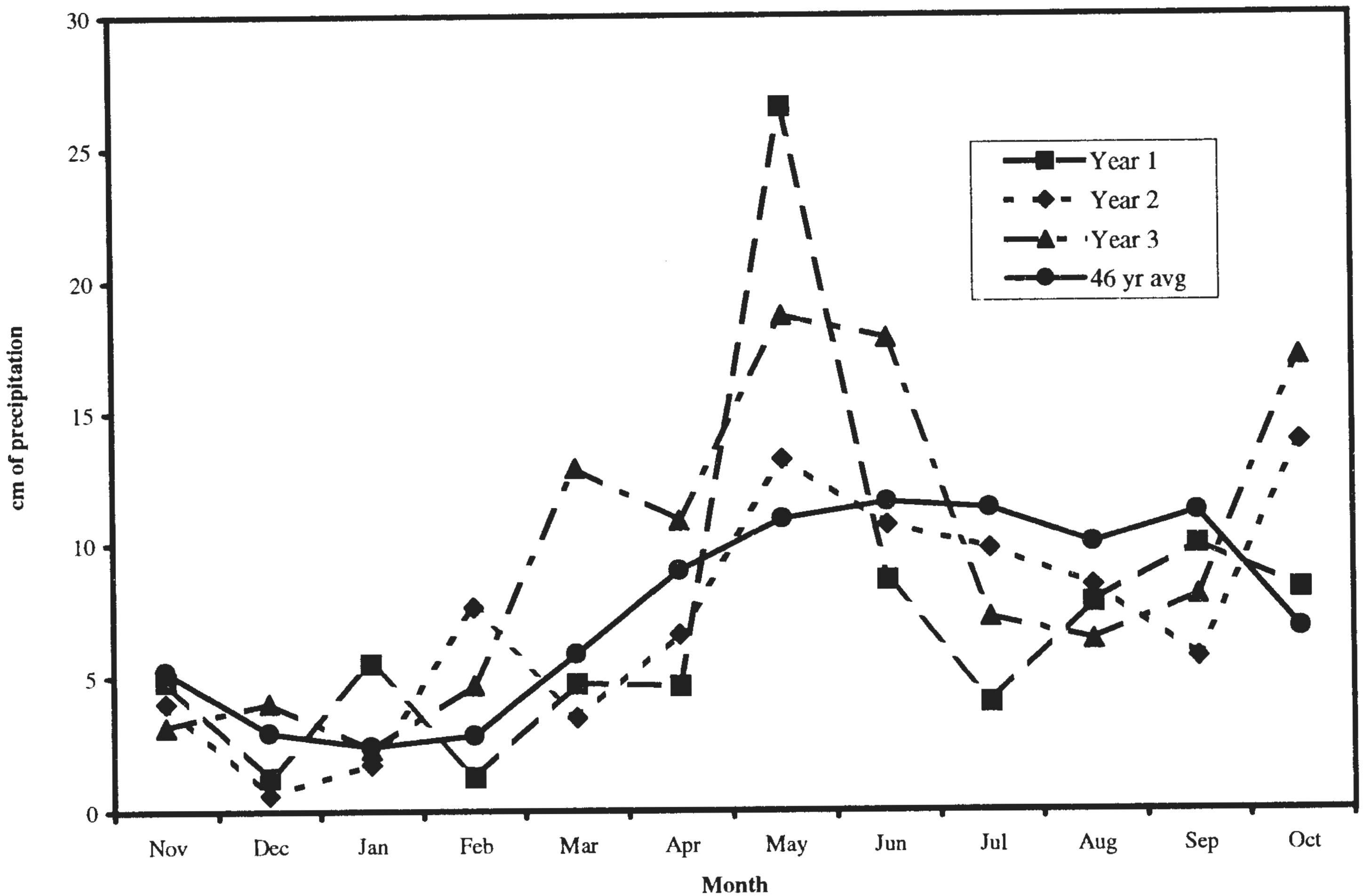

Figure 1. Mean monthly temperatures of three years and 46-year average (1951-1997).

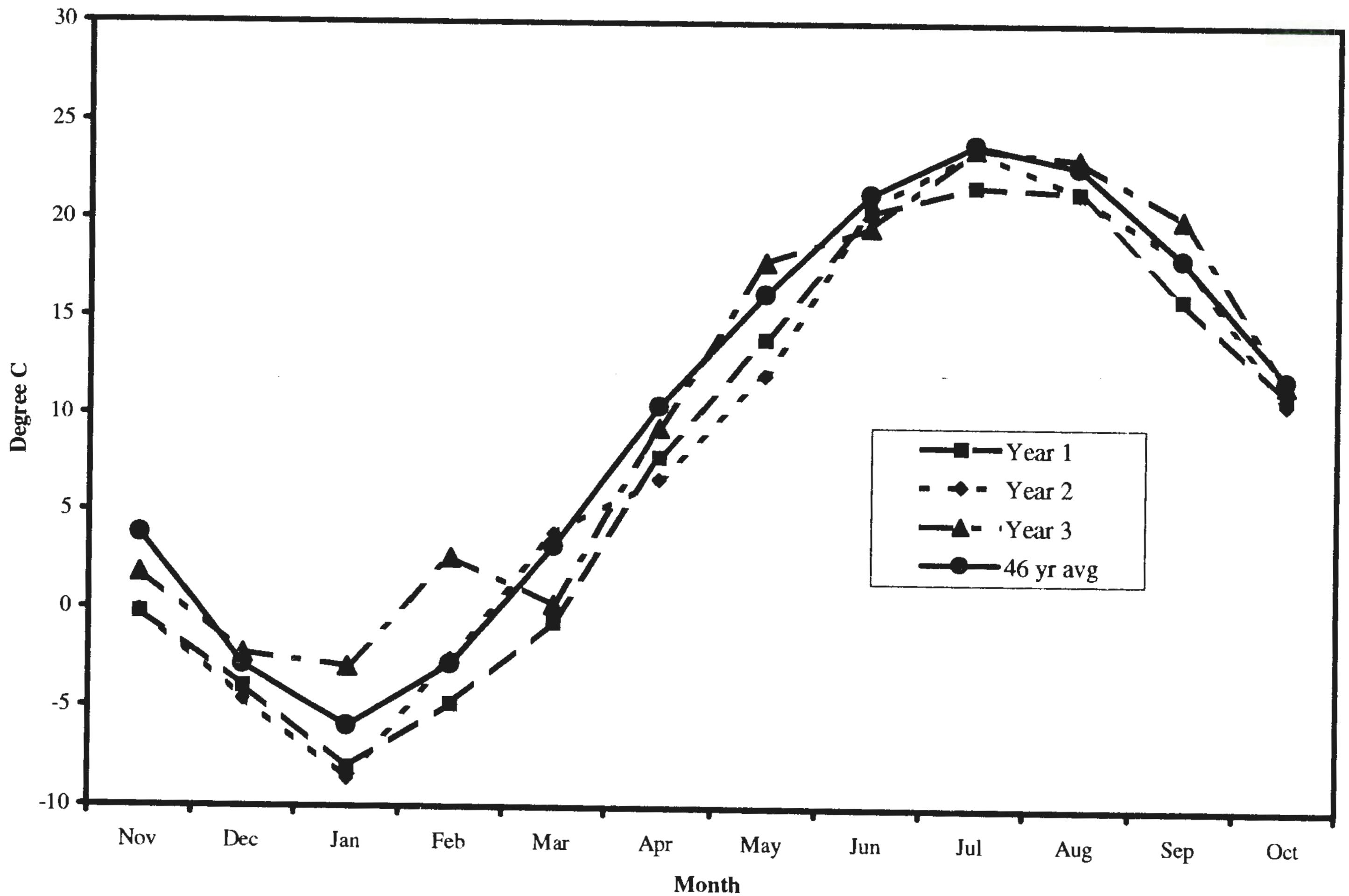

Figure 2. Mean monthly precipitation of three years and 46-year average (1951-1997).

Table 1. Monthly snowfall and ground cover during the winters of 1995, 1996, and 1997

Year	Item	Month						
		Oct	Nov	Dec	Jan	Feb	Mar	Apr
1995	Total snowfall, cm	0	15.24	21.59	58.42	2.54	5.59	0
	Days with snowfall ≥ 2.54	0	2	3	8	1	2	0
	Days with ≥ 2.54 cm of snow on ground	0	7	16	23	13	4	0
1996	Total snowfall, cm	0	0	0	20.57	38.35	0	21.59
	Days with snowfall ≥ 2.54	0	0	0	5	5	0	3
	Days with ≥ 2.54 cm of snow on ground	0	0	0	19	22	0	12
1997	Total snowfall, cm	15.24	1.78	44.96	10.16	2.54	38.1	0
	Days with snowfall ≥ 2.54	2	1	7	2	1	5	0
	Days with ≥ 2.54 cm of snow on ground	4	1	22	15	1	17	0

In yr 3, 45.0 and 38.1 cm of snow was received in December and March, respectively, resulting in 22 and 17 d of snow cover equal or greater than 2.54 cm.

Botanical Composition

Three-year mean proportions of live dry matter were greater ($P > .01$) in the fall than spring sampling date for both tall fescue-red clover and smooth bromegrass-red clover. However, because all other mean botanical compositions of tall fescue-red clover and smooth bromegrass-red clover pastures were not significantly different ($P > .10$) between seasonal sampling dates, means are presented as pooled annual means within years (Table 2). The proportion of total forage DM that was live was 5.7 and 10.9% greater ($P = .02$) in stockpiled tall fescue-red clover and smooth bromegrass-red clover, respectively, in yr 3 compared to the means of yr 1 and 2. The proportion of grass in the live forage increased ($P = .03$) in each year of the experiment. Although red clover was broadcast-seeded in late February into each stockpiled pasture, the proportions of legumes ($P = .03$) and broadleaf weeds ($P = .01$) in the live DM were greater in tall fescue-red clover than in smooth bromegrass-red clover pastures. The proportion of broadleaf weeds in the live DM decreased ($P = .01$) in each year for both forage species mixtures. However, while the proportion of legumes in the tall fescue-red clover pastures decreased each year, the proportion of legume in smooth bromegrass-red clover pasture increased in yr 3 (f x yr, P = .09), resulting in little difference in the botanical composition of the pastures in yr 3.

Herbage Masses and Chemical Composition

At the initiation of grazing, 3-yr average masses of DM ($P = .01$), OM ($P = .03$), and IVOMD ($P = .06$) were greater for corn crop residues (4,880, 4,139, and 2,317 kg/ha) than for stockpiled tall fescue-red clover (3,166, 2,611, and 1,817 kg/ha) or smooth bromegrass-

Table 2. Pooled means of autumn and spring samples of botanical composition of tall fescue-red clover and smooth bromegrass-red clover stockpiled pastures

	Forage species (f) and year (yr)									
	Tall fescue-red clover			Smooth bromegrass-red clover				Significance [a]		
Item	1995	1996	1997	1995	1996	1997	SEM [b]	f	yr	f * yr
% live DM	75.6	73.6	80.3	71.7	70.8	82.2	1.05	NS	.02	NS
% of live DM										
Grass	72.8	79.6	84.0	80.1	91.3	85.5	1.24	.03	.03	NS
Legume	23.6	28.9	14.2	16.4	6.7	14.1	1.78	.03	NS	.09
Weed	3.6	5.0	1.8	2.6	2.1	0.4	.27	.01	.01	NS

[a] NS = not significant (*P* > .10).

[b] Standard error of the mean, n =4.

red clover (2,755, 2,515, and 1,379 kg/ha; Table 3). Dry matter (P = .03), OM (P = .03), and IVOMD (P = .10) masses at the initiation of grazing of all three forages were greater in yr 3 than in yr 1 and 2. Much of this increase may have resulted from the above-normal precipitation that occurred from February to July in yr 3. Furthermore, nitrogen fertilization of the stockpiled forages likely increased herbage masses in yr 2 and 3. In eight 2.97-m^2 areas in each field where nitrogen fertilization was prevented with tarps, forage DM, OM, and IVOMD yields at the initiation of grazing were 19.5, 20.6, and 25.8% lower than fertilized areas in tall fescue-red clover pastures and 7.5, 6.8, and 8.0% lower than fertilized areas in smooth bromegrass-red clover pastures in yr 2. Forage DM, OM, and IVOMD yields of unfertilized areas were 18.3, 18.5, and 35.0% lower than fertilized areas in tall fescue-red clover pastures and 13.4 and 13.7% lower and 3.4% higher than fertilized areas in smooth bromegrass-red clover pastures at the initiation of grazing in yr 3.

Daily loss of DM mass in both grazed and ungrazed areas of pastures were greater (P = .06) from corn crop residues (-16.5 $kg \cdot ha^{-1} \cdot d^{-1}$) than from either stockpiled tall fescue-red clover (-7.0 $kg \cdot ha^{-1} \cdot d^{-1}$) or smooth bromegrass-red clover forage (-4.7 $kg \cdot ha^{-1} \cdot d^{-1}$; Table 4). These losses were greater ($P < .01$) in grazed areas (-17.0 $kg \cdot ha^{-1} \cdot d^{-1}$) than ungrazed areas (-1.7 $kg \cdot ha^{-1} \cdot d^{-1}$) of the fields. The difference in DM losses between grazed and ungrazed areas of the fields were greater (f x g, P = .04) in corn crop residues (34.3 $kg \cdot ha^{-1} \cdot d^{-1}$) than stockpiled tall fescue-red clover (6.9 $kg \cdot ha^{-1} \cdot d^{-1}$) or smooth bromegrass-red clover (4.7 $kg \cdot ha^{-1} \cdot d^{-1}$). Seemingly because of the lower precipitation in November through January, mean DM loss was lower (P = .03) in yr 2 than in yr 1 or 3. Similar to DM, losses of OM and IVOMD were greater ($P < .05$) for corn crop residues than for either stockpiled forage. Furthermore, grazed forages lost greater amounts of OM ($P < .01$) and IVOMD (P = .03) than ungrazed

Table 3. Initial forage mass of dry matter, organic matter, and in vitro organic matter disappearance of corn crop residues, tall fescue-red clover and smooth bromegrass-red clover pastures

	Initial yield, kg/ha		
Forage species (f) and year (yr)	DM	OM	IVOMD
Corn crop residues			
1995	4,218	3,503	1,966
1996	3,978	3,558	2,195
1997	6,445	5,357	2,790
Tall fescue-red clover			
1995	1,955	1,675	1,237
1996	3,261	2,231	1,778
1997	4,283	3,926	2,435
Smooth bromegrass-red clover			
1995	2,105	1,915	1,197
1996	2,449	2,231	1,218
1997	3,712	3,398	1,722
SEM [a]	168.3	154.8	99.1
Significance [b]			
f	.01	.03	.06
yr	.03	.03	.10
f * yr	NS	NS	NS

[a] n = 23.

[b] NS = not significant ($P > .10$).

Table 4. Daily change of dry matter, organic matter, and in vitro organic matter disappearance in forage mass of corn crop residues, tall fescue-red clover, and smooth bromegrass-red clover pastures

Forage species (f) and year (yr)	Daily changes ($kg \cdot ha^{-1} d^{-1}$)					
	DM		OM		IVOMD	
	Grazed[a]	Ungrazed	Grazed	Ungrazed	Grazed	Ungrazed
Corn crop residues						
1995	-29.4	6.3	-26.4	-7.9	-18.2	-3.3
1996	-31.1	4.8	-29.6	-2.8	-22.4	-5.1
1997	-40.4	-8.9	-34.0	-11.9	-21.8	-7.9
Tall fescue-red clover						
1995	-12.6	-6.0	-11.5	-5.5	-8.6	-6.1
1996	-9.8	-2.4	-9.4	-1.8	-6.0	-2.4
1997	-9.0	-2.4	-9.1	-3.7	-9.4	-7.8
Smooth bromegrass-red clover						
1995	-12.1	-6.8	-11.1	-6.2	-7.3	-5.0
1996	-5.2	-5.3	-4.7	-4.5	-2.7	-3.1
1997	-3.8	5.1	-5.6	0.3	-4.0	0
SEM[b]	.47		.56		.40	
Significance[c]						
f	.06		.03		.04	
yr	.03		NS		NS	
f * yr	<.01		.02		.09	
g	<.01		<.01		.03	
f * g	.04		.08		NS	

[a] G = effect of grazing, calculated from day 0, initiation of winter grazing.
[b] n = 38.
[c] NS= not significant ($P < .10$).

forages. The differences in OM and IVOMD loss were greater (f x g, $P = .08$) for corn crop residues (22.5 $kg \cdot ha^{-1} \cdot d^{-1}$) than for stockpiled tall fescue-red clover (6.3 $kg \cdot ha^{-1} \cdot d^{-1}$) and smooth bromegrass-red clover (3.6 $kg \cdot ha^{-1} \cdot d^{-1}$) forage.

At the initiation of grazing, IVOMD concentration of stockpiled tall fescue-red clover forage (64.0%) was greater ($P < .01$) than corn crop residue (55.6%) and stockpiled smooth bromegrass-red clover forage (55.8%; Table 5). In contrast to DM and OM masses the concentrations of IVOMD of stockpiled tall fescue-red clover and smooth bromegrass-red clover forages were lower ($P < .01$) in yr 2 and 3 than yr 1. Concentrations of NDF and ADF at the initiation of grazing were greater ($P < .01$) for corn crop residues (72.7 and 45.3%) than for stockpiled tall fescue-red clover (56.5 and 33.4%) and smooth bromegrass-red clover (59.0 and 36.9%) forage. Mean NDF concentrations of corn crop residues, stockpiled tall fescue-red clover, and stockpiled smooth bromegrass-red clover were lower ($P < .01$) in yr 1 (60.1%) than in yr 2 (63.9%) or 3 (64.2%). However, mean ADF concentrations were lower ($P < .01$) in yr 2 (36.5%) than yr 1 (38.0%) or 3 (41.0%). At the initiation of grazing, CP concentrations of stockpiled tall fescue-red clover (13.1%) or smooth bromegrass-red clover (12.7%) forages were greater ($P < .01$) than corn crop residues (4.9%). Mean CP concentrations of forages at the initiation of grazing in yr 1 (9.2%) were lower ($P < .01$) than those in yr 2 (10.9%) and 3 (10.6%) when the stockpiled forages were fertilized with nitrogen. The mean proportion of nitrogen as ADIN at the initiation of grazing was greater ($P = .01$) for corn crop residues (22.7%) than for stockpiled tall fescue-red clover (18.2%) or smooth bromegrass-red clover (18.9%) forage. Mean ADIN concentrations of corn crop residues and stockpiled forages were greater ($P < .01$) in yr 2 (22.9%) and 3 (21.8%) than yr 1 (15.0%). While there was little difference in the proportion of nitrogen as ADIN between

Table 5. Initial chemical composition concentrations of corn crop residues, tall fescue-red clover, and smooth bromegrass-red clover pastures

	Initial concentration, % of OM				
Forage species (f) and year (yr)	IVOMD	NDF	ADF	CP	ADIN, % of N
Corn crop residues					
1995	56.1	72.3	45.1	4.3	14.8
1996	60.7	71.5	41.9	5.6	16.0
1997	50.0	74.3	48.8	4.9	37.3
Tall fescue-red clover					
1995	69.9	52.1	31.9	11.9	13.7
1996	60.0	57.6	33.7	14.1	25.5
1997	62.0	59.8	34.5	13.4	15.3
Smooth bromegrass-red clover					
1995	62.5	56.0	37.1	11.5	16.6
1996	54.6	62.6	34.0	13.1	27.2
1997	50.4	58.5	39.6	13.4	12.9
SEM [a]	7.3	3.4	4.9	.17	.93
Significance [b]					
f	<.01	<.01	<.01	<.01	.01
yr	<.01	<.01	<.01	<.01	<.01
f * yr	.03	<.01	NS	NS	<.01

[a] n = 23.
[b] NS = not significant ($P < .10$).

species in yr 1, the proportion of ADIN in stockpiled forages was greater than corn crop residues in yr 2, and the proportion of ADIN in corn crop residues was greater than stockpiled forages in yr 3 (f x yr, $P < .01$).

Mean daily decrease in IVOMD concentration was greater ($P = .04$) from corn crop residues (-.11% OM/d) and stockpiled tall fescue-red clover forage (-.12% OM/d) than from smooth bromegrass-red clover forage (-.04% OM/d; Table 6). In yr 2, the IVOMD concentration of corn crop residues decreased at a greater rate than either of the stockpiled forages, but in yr 3, IVOMD concentration of stockpiled tall fescue-red clover forage decreased at a more rapid rate than either corn crop residues or stockpiled smooth bromegrass-red clover forage (f x yr, $P = .01$). Apparently because of the lower concentration of NDF of the forages at the initiation of grazing in yr 1 than in subsequent years, the rate of NDF increase during the winter was greater ($P < .01$) in yr 1 (.08% OM/d) than in yr 2 (.04% OM/d) and 3 (.01% OM/d). The rate of NDF increase of stockpiled tall fescue-red clover forage (.06% OM/d) was greater ($P = .01$) than corn crop residues (.04% OM/d) or stockpiled smooth bromegrass-red clover forage (.04% OM/d). and was greater in grazed (.06% OM/d) than ungrazed (.03% OM/d) areas. The difference in NDF increase between grazed and ungrazed areas was greater ($P < .01$) in corn crop residues (.12% OM/d) than stockpiled tall fescue-red clover (0% OM/d) and smooth bromegrass-red clover (0% OM/d). Similar to NDF, the rate of increase in ADF concentration of corn crop residues and stockpiled forages was greater in yr 1 than in yr 2 and 3. Mean daily increase in ADF concentration was greater ($P = .01$) for corn crop residues (.05% OM/d) than stockpiled tall

Table 6. Daily changes of chemical composition of corn crop residues, tall fescue-red clover and smooth bromegrass-red clover pastures

Item and year (yr)	Forage species (f) and grazing (g): Corn crop residues, Grazed[b]	Corn crop residues, Ungrazed	Tall fescue-red clover, Grazed	Tall fescue-red clover, Ungrazed	Smooth bromegrass-red clover, Grazed	Smooth bromegrass-red clover, Ungrazed	SEM[c]	Significance[a]: f	g	yr	f * g
			% units OM/d								
IVOMD											
1995	-.14	-.05	-.13	-.14	-.06	-.09	.007	.04	NS	NS	.01
1996	-.18	-.12	-.06	-.06	-.02	-.04					
1997	-.12	-.04	-.14	-.16	-.01	-.01					
NDF											
1995	.11	0	.10	.12	.10	.07	.004	.01	<.01	<.01	<.01
1996	.10	0	.04	.05	0	.03					
1997	.07	-.05	.01	.01	.02	.02					
ADF											
1995	.14	.03	.06	.06	.03	.03	.004	.01	<.01	.01	<.01
1996	.07	.03	.02	.03	.01	.03					
1997	.07	-.03	.02	.02	-.01	0					
CP											
1995	-.02	0	-.02	-.01	0	-.01	.12	NS	NS	<.01	.03
1996	-.01	.01	0	-.01	.01	-.01					
1997	-.01	.01	.01	.01	.01	.01					
ADIN			% units N/d								
1995	-.01	-.06	.05	.04	.02	.01	.11	NS	NS	<.01	.08
1996	-.1	.10	-.08	-.09	-.11	-.12					
1997	.08	.10	.07	.08	.10	.13					

[a] f = forage species, y = year, g = effect of grazing, NS = not significant ($P > .10$).
[b] All values calculated from initiation of corn crop residue grazing.
[c] n = 38.

fescue-red clover (.04% OM/d) or smooth bromegrass-red clover (.01% OM/d). Acid detergent fiber concentration increased more in grazed (.09% OM/d) than ungrazed (.01% OM/d) corn crop residues, but grazed stockpiled forages had equal or lower rates of change in ADF concentration than ungrazed stockpiled forages (f x g, $P < .01$). Forage species and grazing did not affect loss of CP ($P > .10$). Losses of CP were greater in yr 1 ($P < .01$) in corn crop residues, stockpiled tall fescue-red clover and smooth bromegrass-red clover. Crude protein concentrations decreased more in grazed (-.01% OM/d) than ungrazed (.01% OM/d) corn crop residues, but the rate of change of CP did not differ between grazed and ungrazed stockpiled forages (f x g, $P = .03$). Neither forage species nor grazing affected ($P > .10$) daily changes in ADIN concentration. Loss of ADIN concentration occurred in corn crop residues in yr 1 and 2, and in stockpiled forages in yr 2 ($P < .01$).

Cow Body Weight and Condition Scores

As allotted each year, there were no differences ($P > .10$) in the mean BW or condition scores of the cows (Figure 3). Over the 3 yr of the experiment, cows in the year-round grazing systems lost greater ($P < .05$) amounts of BW and condition score while grazing corn crop residues than cows maintained in a drylot. This effect was significant ($P < .05$) in yr 1 and 3. Although hay feeding was supposed to be regulated to maintain a condition score of 5, most of the decrease in body condition occurred during the last 2 or 3 wk of corn crop residue grazing immediately prior to initiation of stockpiled forage grazing. During the period from the initiation of grazing of the stockpiled forages to the initiation of the calving season, there were no differences ($P > .10$) in the mean changes in BW or condition score between cows grazing stockpiled forages and those maintained in a drylot. However, cows grazing stockpiled forages during this period had greater ($P < .05$) BW losses

Figure 3. Mean bodyweight and condition score of cows at the initiation, termination of corn crop residue grazing in December, (Period 1), initiation of calving in March (Period 2), and termination of winter grazing (Period 3) over 3 years.

	SEM (n = 6)	
	Bodyweight	Condition Score
Initial	2.01	.06
Period 1	3.03	.07
Period 2	7.55	.07
Period 3	1.53	.03

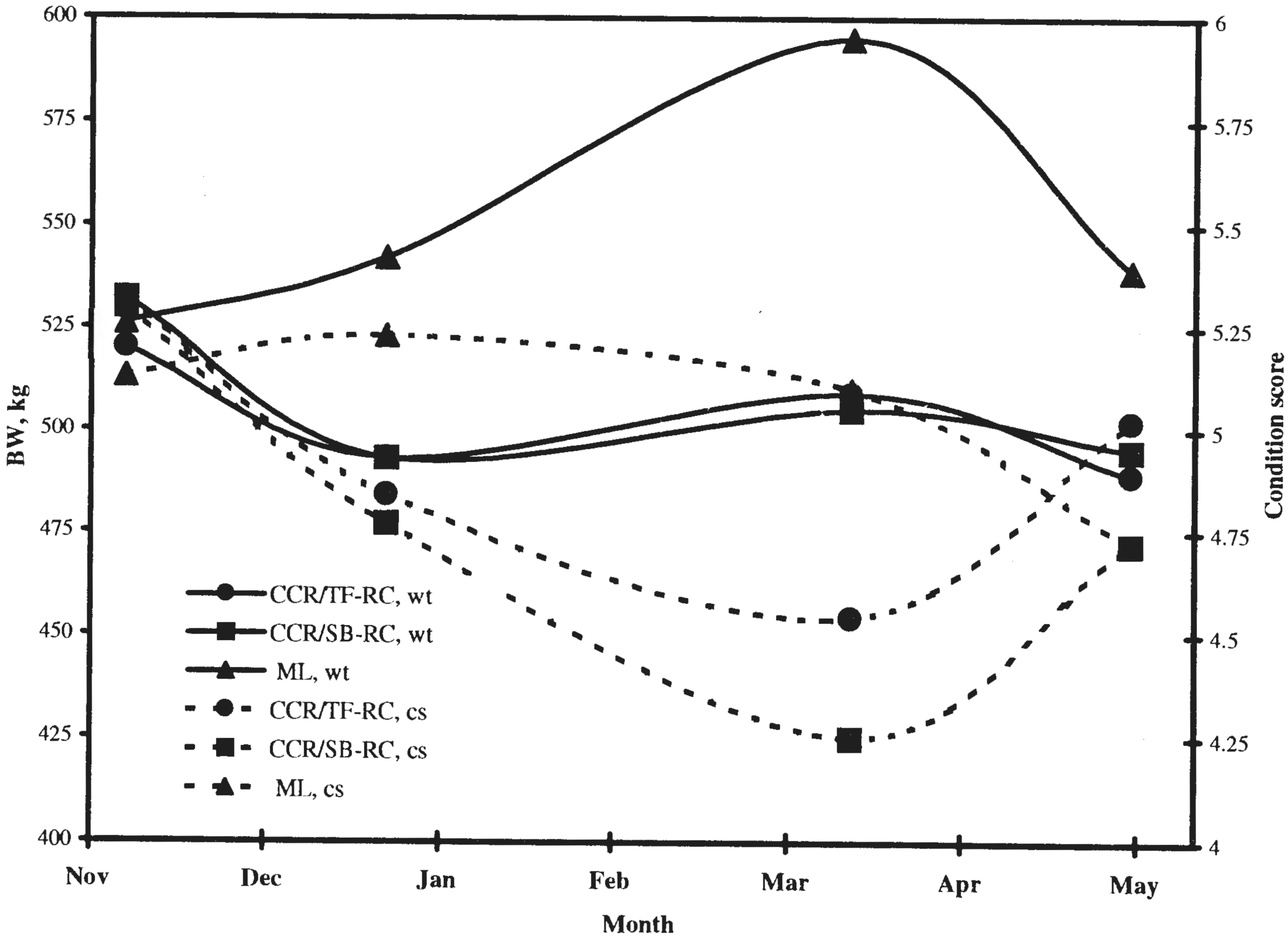

Figure 3. (continued)

in yr 1, and cows grazing stockpiled smooth bromegrass-red clover had a greater ($P < .05$) loss of body condition than cows maintained in a drylot in yr 3. During the period from the initiation of calving in March to the initiation of summer grazing in early May, cows grazing stockpiled forages lost less ($P < .05$) BW and gained more ($P < .05$) body condition than cows maintained in a drylot. The differences in BW change between cows grazing stockpiled forages or maintained in a drylot during the calving season were greatest ($P = .05$) during yr 1 and 3 when the greatest differences in BW change during corn crop residue grazing had occurred. The differences in condition score change between cows grazing stockpiled forages or maintained in a drylot during the calving season occurred in each year. As a result of differences occurring at different periods of the winter, seasonal changes in BW and condition score did not differ ($P > .05$) between cows sequentially grazing corn crop residues and stockpiled forages or maintained in a drylot. Similarly, rebreeding rates after a 48-d period of natural service in the summer were 95% and did not differ between winter treatments.

Stored Hay Feeding and Recovery

As expected, cows that were fed hay in drylots consumed greater ($P < .05$) amounts of stored hay than cows grazing corn crop residues followed by stockpiled forages (Table 7). Mean hay consumption of cows in drylots was 2,869 kg of hay DM per cow in contrast to 154 and 199 kg of hay DM per cow for cows grazing corn crop residues and stockpiled tall fescue-red clover or smooth bromegrass-red clover. Hay feeding to grazing cows in yr 2 and 3 was limited to one time each year when heavy snowfall prevented grazing for several days in late winter. Hay balance was greater ($P < .05$) for grazing systems utilizing corn crop residues and stockpiled tall fescue-red clover (3,116 kg DM/cow) or smooth bromegrass-red

Table 7. Stored hay use and hay balance of cows in three winter forage systems

	Winter system			
	CCR/TF-RC	CCR/SB-RC	Drylot	SEM [d]
Hay fed, kg DM/cow				
1995	365[b]	452[b]	2,815[c]	18.27
1996	51[b]	52[b]	3,347[c]	8.70
1997	48[b]	92[b]	2,445[c]	19.24
Avg.	154[b]	199[b]	2,869[c]	9.66
Hay balance, kg DM/cow [a]				
1995	5,405[b]	5,813[b]	-1,418[c]	129.13
1996	2,236[b]	2,298[b]	-2,114[c]	100.66
1997	1,708[b]	1,930[c]	-1,300[e]	18.76
Avg.	3,116[b]	3,347[b]	-1,611[c]	68.92

[a] Hay balance = amount of hay harvested per cow- amount of hay fed per cow.

[b c e] Means with different superscripts are significant, ($P < .05$).

[d] n = 6.

clover (3,447 kg DM/cow) than the system in which cows were maintained in drylots (-1,611 kg DM/cow). The difference in hay balance resulted both from the grazing of forages during winter by cows grazing corn crop residues and stockpiled forages and the areas of hay harvested (1.25 vs. .25 to .5 ha/cow) in the winter grazing and drylot maintenance systems. The decline in hay balance in the winter grazing systems from yr 1 to yr 2 and 3 was caused by the reduction in the number of hay harvests from two in the summer preceding yr 1 to one in the summers preceding yr 2 and 3.

The proportions of hay DM and OM recovered and the concentrations of IVOMD and CP did not differ ($P > .10$) between tall fescue-red clover and smooth bromegrass-red clover hays in November (mean values; 100.2, 100.1, 54.2, and 12.6%) and March (mean values; 97.2, 99.9, 55.5, and 12.6%).

Forage Selection and Intake

During determination of forage selection, 3-yr mean DM allowances of forage available for cows and fistulated steers were 130.8 and 25.3 $kg \cdot cow^{-1} \cdot d^{-1}$ while grazing corn crop residues or feeding of hay in November and 21.7, 18.2, and 20.6 $kg \cdot cow^{-1} \cdot d^{-1}$ while grazing stockpiled tall fescue-red clover and smooth bromegrass-red clover or feeding of hay in March.

Mean selection indices for OM in November and March of each year by fistulated steers fed hay were 95.7 and 96.3%, implying little soil contamination of the baled hay (Table 8). Because the selection indices for IVOMD by hay-fed steers were 146.7 and 127.7% in November and March, it seems that steers had a strong tendency to consume hay from the unweathered bale cores as opposed to the outside of the bales (Russell and Buxton, 1985). However, selection indices for CP, NDF, and ADF by hay-fed steers in November

Table 8. Three-year mean chemical composition of selected forage and selection indices of hay and corn crop residues in November, and hay, stockpiled tall fescue-red clover and smooth bromegrass-red clover in March by steers offered hay or grazing

	Component				
	OM	IVOMD	CP	NDF	ADF
			November		
			Composition		
	% DM	---	% of OM	---	---
Hay	87.4	69.0	12.2^{a}	66.4	44.3^{a}
Corn crop residues	86.3	76.9	8.7^{b}	69.8	41.5^{b}
SEM (hay; n = 6)	1.11	3.60	.89	1.92	.64
SEM (ccr; n = 12)	.78	2.55	.63	1.36	.45
			Selection indices [d]		
Hay	95.7	146.7	128.3^{a}	103.0^{a}	112.5^{a}
Corn crop residues	104.1	165.3	197.8^{b}	89.0^{b}	84.2^{b}
SEM (hay; n = 6)	4.19	12.19	18.09	1.92	3.11
SEM (ccr; n = 12)	2.96	8.62	12.79	1.36	2.20
			March		
			Composition		
	% DM	---	% of OM	---	---
Hay	88.3^{a}	72.1	13.6^{ab}	67.3^{a}	41.0^{a}
Tall fescue-red clover	86.2^{b}	69.8	13.8^{a}	63.2^{b}	38.3^{b}
Smooth bromegrass-red clover	86.5^{b}	70.3	13.4^{b}	63.1^{b}	38.8^{b}
SEM (n = 6)	.70	1.06	.12	.93	.62
			Selection indices		
Hay	96.3	127.7^{a}	108.0	108.0^{a}	113.0^{a}
Tall fescue-red clover	96.1	151.1^{b}	111.7	100.3^{b}	101.0^{b}
Smooth bromegrass-red clover	99.0	151.5^{b}	103.3	100.2^{b}	104.6^{b}
SEM (n = 6)	1.44	5.05	4.24	1.55	3.04

[a, b, c] Differences in means in columns for composition or selection indices in a given month with different superscripts are significant ($P < .05$).

[d] Ratio of concentration in selected forage to concentration in available forage.

and March also were greater than 100%. These indices may imply that, at least during the 2-d period over which selection was determined, steers selectively consumed portions of the bale that had higher concentrations of these components, or the method of core-sampling at two depths underestimated the contribution of the composition of the weathered outer layer of the bale to the composition of the whole bale.

In November of each year, forage consumed by hay-fed steers had greater ($P < .05$) concentrations of CP and ADF than forage consumed by steers grazing corn crop residues, seemingly caused by grazing selection. Mean selection index for CP was 70.5% greater ($P < .05$) and mean selection indices for NDF and ADF were 14.1 and 28.3% lower ($P < .05$) for steers grazing corn crop residues than for those fed hay. This greater selectivity results from the greater forage allowance per animal (Russell et al., 1993) and the variation in the nutritive values of the different components of the corn crop residues (Gutierrez-Ornelas and Klopfenstein, 1991; Hitz and Russell, 1998). In March, forage consumed by steers grazing stockpiled forages contained lower ($P < .05$) concentrations of OM, NDF, and ADF than hay-fed steers. Selection indices for OM and CP did not differ ($P > .10$) between fistulated steers grazing stockpiled tall fescue-red clover or smooth bromegrass-red clover, or fed hay. However, whereas the NDF and ADF concentrations of steers grazing stockpiled forages differed little in selected forages, forages consumed by hay-fed steers had higher NDF and ADF concentrations than hay fed. There was no difference in the IVOMD concentrations of forage selected by steers fed hay or grazing stockpiled forages as a result of selection. The selection indices for IVOMD were greater ($P = .05$) for steers grazing stockpiled tall fescue-red clover or smooth bromegrass-red clover than for those consuming hay in a drylot. The ability to select forage with a higher IVOMD concentration seemingly resulted from the use of a strip-grazing system that controlled access to ungrazed forage and from the estimated grazing efficiency of 51.1%.

In November, mean DMI, expressed as kg/d or percentage of BW, was greater (P = .05) by cows fed hay (9.4 kg/d or 1.65% BW) than in those grazing corn crop residues (6.6 kg/d or 1.28% BW; Table 9). However, while hay-fed cows consumed 4.9 and 6.6 kg more hay DM/d than did cows grazing corn crop residues in yr 1 and 3, cows grazing corn crop residues consumed 1.6 kg more forage DM/cow than cows fed hay in yr 2 (f x yr, P = .05). Mean DMI of cows grazing stockpiled tall fescue-red clover or smooth bromegrass-red clover forage or fed hay in March were 11.8 kg/d or 2.23 % BW and did not differ (P > .10) between forage systems.

Discussion

Because of the higher concentrations of IVOMD and CP at the initiation of grazing and/or lower rates of loss in IVOMD concentration over the winter, stockpiled forages had a higher nutritive value than corn crop residues at any date during the winter. Similar changes in forage composition have been observed by others (Adams et al., 1986; Hitz and Russell, 1998; Johnson et al., 1998). Thus, steers grazing stockpiled grass-legume mixtures were able to select a diet with similar concentrations of IVOMD and higher concentrations of CP in March than those grazing corn crop residues in November. Furthermore, while the IVOMD concentration of stockpiled forages is lower than hay in March, because cows are able to selectively graze stockpiled forages, they consume a diet with equal IVOMD concentration than cows fed grass-legume hay if a stockpiled forage allowance of at least 18.2 $kg \cdot cow^{-1} \cdot d^{-1}$ is provided. Thus, the concept of sequentially stocking corn crop residues followed by

Table 9. Three-year mean dry matter intakes of cows consuming corn crop residue or hay in November, and stockpiled tall fescue-red clover or smooth bromegrass-red clover or hay in March

	Winter system			
Item	CCR/TF-RC	CCR/SB-RC	Drylot	SEM [a]
		November		
DMI, kg	7.7[b]	5.6[c]	9.4[b]	.66
DMI, % BW	1.47[b]	1.09[c]	1.65[b]	.12
BW, kg	525	508[b]	555[c]	11.06
		March		
DMI, kg	11.9	13.5	10.0	1.70
DMI, % BW	2.27	2.66	1.76	.33
BW, kg	529[b]	514[b]	580[c]	11.43

[a] n = 12.

[b,c] Differences between means with different superscripts within year are significant ($P < .05$).

stockpiled grass-legume forages for spring-calving cows in place of hay feeding seems justified.

Over 3 yr, supplemental hay requirements for cows sequentially stocking corn crop residues and stockpiled grass-legume forages at .61 and 1.22 ha/cow over 55 and 130 d respectively, reduced supplemental hay needs by 2,670 to 2,715 kg DM/cow to maintain equal body condition score changes to cows maintained in a drylot. Hitz and Russell (1998) reported cows grazing for 139 d at .82 cows/ha reduced supplemental hay needs by 1,031 to 1,069 kg DM/cow compared with cows maintained in a drylot at equal body condition scores. Allen et al. (1992) reported cows grazing stockpiled tall fescue-red clover at .33 ha/cow with required 646 kg/cow of hay for the period of November to April. Adams et al. (1984) observed reductions of 2,032 kg of hay DM/cow with grazing of winter range and May meadow compared to all hay feeding. In this experiment, supplemental hay for grazing cows was required primarily because of weather conditions rather than inadequate forage allowance, particularly in yr 2 and 3 when stockpiled forage yields were increased by nitrogen fertilization. The 18.9 and 10.5% increases in stockpiled tall fescue-red clover and smooth bromegrass-red clover forage yields resulting from nitrogen fertilization were consistent with those observed by others (Archer and Decker, 1977; Gerrish et al., 1994). The negative hay balance for cows maintained in drylots implies that a greater amount of land was required for hay production than the .25 to .50 ha/cow that was provided in this experiment. Utilizing the mean hay yields during the 3 yr of 3,059 DM kg /ha, .47 ha/cow of additional land for hay production would be required to meet the hay needs of the cows maintained in a drylot. In contrast, excess summer forage is produced from the area that is needed for winter-stockpile forage grazing, which must be utilized by grazing of extra animals or hay harvest to optimize forage utilization.

While no differences in BW or body condition score changes were observed between cows sequentially stocked on corn crop residues and stockpiled grass-legume forages or fed hay in a drylot between the initiation and termination of the winter feeding season, differences in these changes were observed during the winter feeding season. Cows that grazed corn crop residues from October through December lost an average of 33 kg and .5 condition score units compared to gains of 16 kg and .1 body condition score units by cows fed hay during the same period. Losses of body condition from January to March averaged .41 units for cows grazing stockpiled forage and .13 for cows offered hay but did not significantly differ between cows grazing stockpiled forages or fed hay in a drylot. Such a decrease in late gestation often is observed because of the mobilization of fat tissue and fetal protein deposition (Thompson et al., 1983) and is not detrimental to subsequent reproduction if adequate energy to increase body condition is provided in early lactation (Houghton et al., 1990; Sinclair et al., 1994, Wright et al., 1992). Freetly and Nienaber (1998) observed that the efficiency of energy and nitrogen retention increased with elevation of feeding after a period when the level of feeding was limited to cause a reduction in BW. In this experiment, cows grazing stockpiled forages from March to May had increased body condition scores concurrently with increases in nutrient requirements because of the onset of lactation, while cows offered hay in drylots lost BW and condition score. Therefore, it seems that cows in the grazing systems may have utilized forage nutrients more efficiently in early lactation than cows maintained in drylots. Further evidence of this relationship was shown with the NRC Nutrient Requirements for Beef Cattle Program (NRC, 1996), which, based upon the forage selection and intake data obtained in March, predicted that cows grazing stockpiled tall fescue-red clover and smooth bromegrass-red clover forages in March should lose 1.0 unit of condition score over 109 d and gain 1.0 unit of condition score over 158 d, respectively. Meanwhile, cows in the drylot were predicted to lose 1.0 unit of condition score over 190 d. In contrast to these predictions, the body condition score of cows grazing stockpiled tall fescue-red clover forages increased by .5 units over 50 d, and cows grazing stockpiled smooth bromegrass-red clover gained .5 units in one-half of the time predicted. Concurrently, those of cows fed hay in a drylot decreased by .4 units over 50 d, nearly twice as fast as predicted. While some of this improved performance by grazing cows may have resulted from the small amount of new forage growth that occurred in the stockpiled forage fields in early spring, this small amount of new growth seems unlikely to have caused the major changes in condition score observed relative to the increased cow nutritive requirements. Therefore, it seems that the pattern of fluctuation in BW and condition score occurring in cows in the winter gazing system may have improved the efficiency of nutrient utilization of these cows in late gestation and early lactation.

Implications

These results imply that winter grazing of corn crop residues and stockpiled forages with gestating mature cows can maintain animals at equal or greater body condition as feeding hay to cows in a drylot. Increases in body weight and body conditions score have been shown to be beneficial in cow maintenance and subsequent rebreeding rates. By grazing corn crop residues, cows can utilize a forage resource that meets maintenance needs in the early winter. Stockpiled forages with nitrogen fertilization can provide adequate quality forage for extending the grazing season into the late winter and early spring.

Extension of the grazing season by any extent would therefore reduce the amount of stored feed required for winter maintenance of mature beef cows.

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EVALUATION OF YEAR-ROUND FORAGE MANAGEMENT SYSTEMS FOR BEEF COW-CALF PRODUCTION:

II. SUMMER SYSTEMS[1]

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ABSTRACT

A 3-yr experiment was conducted to compare production of calves, stockers, hay, and stockpiled forage from cool season grass-legume pastures as the summer portion of different year-round forage management systems. In May of each year, 16 crossbred cows with calves were allotted to four 4.05-ha smooth bromegrass-orchardgrass-birdsfoot trefoil pastures to graze 2.03 to 2.53 ha by rotational stocking (minimal land system). First growth forage was harvested as hay from the remaining 1.52 to 2.02 ha in mid-June. After regrowth, cow-calf pairs were allowed to graze each entire pasture until November. Calves were weaned in November and finished on a high grain diet. In the year-round grazing system, 20 crossbred cows with calves and 20 yearling cattle were allotted to four 4.05-ha smooth bromegrass-orchardgrass-birdsfoot trefoil pastures to graze by rotational stocking for a mean of 40 d beginning in May. Cow-calf pairs in this system and one bull were moved to four 6.05-ha pastures containing second growth endophyte-free tall fescue-red clover or smooth bromegrass-red clover to strip-graze for a mean of 47 d following first cutting hay harvest. In August, yearlings were placed in a feedlot for finishing on a high grain diet, and cow-calf pairs were returned to the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures to graze until November. Herbage masses of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures where yearlings grazed in June and July were greater ($P < .05$) than smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land system or tall fescue-red clover and smooth bromegrass-red clover pastures of the year-round grazing systems that cow-calf pairs grazed. In June and July, IVDMD concentrations of forage from smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land system were greater ($P < .05$) than tall fescue-red clover or smooth bromegrass-red clover pastures. Seasonal calf

weight gains ($P < .05$), growing animal weight gains ($P < .05$), and total winter forage production ($P < .05$) from the minimal land, year-round grazing system with tall fescue-red clover, and year-round grazing system with smooth bromegrass-red clover were 193, 193, 1,272; 95, 142, 5,926; and 88, 133, 5,936 kg/ha respectively. To obtain a backfat thickness of 1.0 cm, feeding 1,695 and 1,354 DM kg/animal of a high grain diet ($P < .10$) was required for calves from the minimal land system and yearlings from the year-round grazing systems.
Key Words: Beef Cattle, Grazing, Rotational Stocking

Introduction

In order to optimize milk production and reproductive efficiency of beef cows, a high level of postpartum nutrition is necessary, particularly in cows with low body condition at parturition (Houghton et al., 1990; Wright et al., 1992; Sinclair et al., 1994). Increased fatness, milk production, and calf growth in beef cows has been achieved by increasing the nutritive value of pasture forage (Holloway et al., 1985).

Because forage production of cool season species in Midwestern pastures is greatest in spring, forage maturity and nutritive value are difficult to control when grazing at a set stocking rate for an entire grazing season (Marten and Jordan, 1972). Therefore, utilization of excess forage early in the grazing season is necessary to maintain the nutritional value of pasture forage (Tallowin et al., 1986).

Grazing of stockpiled forages reduces the amount of hay required to maintain gestating beef cows compared with maintenance in a drylot during winter (Hitz and Russell, 1998; Hersom et al. 2000). Forage produced in early summer before stockpiling begins, however, must be harvested to maintain the production efficiency of the system and prevent stockpiled forage from becoming excessively mature (Fribourg and Bell, 1984; Collins and

Balasko, 1981). Therefore, pastures used for winter grazing of stockpiled forage increase the total amount of forage available for use in early summer.

Forage production and nutrient quality in pastures has been controlled by hay harvest (Fontenot et al., 1993) or by increasing stocking density in early spring (Tallowin, 1986). Such management practices not only improve pasture forage quality, but also provide stored forages or animal weight gains as outputs of the management systems that must be considered.

The objective of this experiment was to compare forage production and nutritive value, cow-calf production, and yearling cattle production from different management systems utilizing smooth bromegrass-orchardgrass-birdsfoot trefoil with or without tall fescue-red clover or smooth bromegrass-red clover pastures.

Materials and Methods

Pastures

A 3-yr forage management experiment was conducted on eight 4.05-ha pastures containing smooth bromegrass, orchardgrass, and birdsfoot trefoil and four 6.07-ha pastures containing red clover with endophyte-free tall fescue or smooth bromegrass at the McNay Research and Demonstration Farm near Chariton, Iowa. In 1989, eight 4.05-ha pastures were fertilized according to recommendations and seeded either with smooth bromegrass (*Bromus inermis* var. Barton) and orchardgrass (*Dactylis glomerata* var. Napier) at seeding rates of 11.2 and 5.6 kg/ha or smooth bromegrass (*Bromus inermis* var. Barton), orchardgrass (*Dactylis glomerata* var. Napier), and birdsfoot trefoil (*Lotus corniculatus* var. Norcen) at seeding rates of 9.0, 6.7, and 3.4 kg/ha, respectively. While establishment of birdsfoot trefoil was satisfactory, grass establishment was inhibited by drought. Therefore, all grasses were reseeded in 1990, and the pastures were utilized in grazing experiments from 1991 through 1995. Because birdsfoot trefoil was not planted in half of the pastures and was lost from pastures originally seeded with birdsfoot trefoil, birdsfoot trefoil was broadcast-seeded at 9.0 kg/ha into all pastures in early March of 1996. Each pasture was divided into eight paddocks before being used for grazing in 1996. Tall fescue-red clover and smooth bromegrass-red clover pastures were established in 1991 and managed until 1995 as described in a companion paper (Hersom et al., 2000).

Management Systems

On May 1, 1996 (yr 1), May 7, 1997 (yr 2), and April 28, 1998 (yr 3), 36 medium-frame Simmental x Angus x Jersey cows (mean BW, 514 kg; mean body condition score, 4.89) with calves from the winter management treatments described in a companion paper (Hersom et al., 2000) were stocked on the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures at 1.01 ha/cow-calf pair in the minimal land system or at .81 ha/cow-calf pair with yearling cattle (mean BW, 288 kg) at .81 ha/yearling in the year-round grazing system. For the first 41, 34, and 29 d of yr 1, 2, and 3, animals in both management systems were moved between paddocks daily. In the minimal land system, 1.52 ha in yr 1 and 2.02 ha in yr 2 and 3 of each pasture were deferred from grazing for the production of one cutting of hay harvested as large round bales on July 1, June 17, and June 22 in yr 1, 2, and 3, respectively. Paddocks that were deferred for hay harvest were incorporated into the grazing system after 7 d while cows were confined to a harvested paddock and fed hay in yr 1 because of inadequate forage for grazing, and after 36 and 29 d of regrowth in yr 2 and 3. Thereafter, pastures were rotationally stocked to remove approximately 33% of standing forage based on two sward height measurements per paddock with a falling plate meter (4.8 kg/m^2) until

October 30, October 29, and November 11 in yr 1, 2, and 3, respectively. Cows were bred by natural service over 56, 43, and 43 d of beginning on June 11, June 26, and June 24 in yr 1, 2, and 3.

In the year-round grazing systems, first-cutting forage was harvested as hay from 4.55 ha in yr 1 and 6.07 ha in yr 2 and 3 of the tall fescue-red clover and smooth bromegrass-red clover pastures simultaneous to hay harvest from the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land system. Because of inadequate forage availability in the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in yr 1, cow-calf pairs in the year-round grazing system were moved to 1.52 ha of the tall fescue-red clover or smooth bromegrass-red clover pastures to strip-graze first harvest forage for 34 d. Second harvest forage in the tall fescue-red clover or smooth bromegrass-red clover pastures were strip-grazed at 1.21 ha/cow-calf pair for 24, 42, and 43 d by cows and calves after periods of 12, 17, and 28 d of regrowth in yr 1, 2, and 3. Breeding of cows occurred by natural service over 56, 42, and 43 d beginning on June 11, June 26, and June 24, while cows grazed tall fescue-red clover or smooth bromegrass-red clover pastures in yr 1, 2, and 3. Simultaneous to grazing of the tall fescue-red clover or smooth bromegrass-red clover pastures, yearling cattle continued to graze the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures by rotational stocking. In early August, yearlings were removed from the pastures and the cow-calf pairs returned to the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures to graze by rotational stocking. Movement between paddocks was adjusted to remove 33% of the standing forage based on sward height until October 30, October 29, and November 11 in yr 1, 2, and 3. After removal of cows and calves from the tall fescue-red clover and smooth bromegrass-red clover pastures in early August, pastures were fertilized with ammonia nitrate at 44.8 kg N/ha and forage was allowed to stockpile for winter grazing.

Death losses of 1, 3, and 2 calves in yr 1, 2, and 3 required the replacement of cow-calf pairs prior to the initiation of summer grazing. Replacement cow-calf pairs were of similar body weight and condition score as those that they replaced.

All cows, suckling calves, and yearlings were weighed unshrunk at the initiation of summer grazing, at the initiation of the breeding season, at termination of the breeding season, and at termination of summer grazing. Cow body condition score was assessed by a single individual, simultaneous to weighing, by visual scoring on a 9-point scale (Neumann and Lusby, 1986). Conception and the approximate length of pregnancy was determined by rectal palpation 47 d after termination of the breeding season.

Each November, weaned calves from the summer grazing treatments were blocked by weight and sex and allotted to two subsequent treatments. In yr 1, calves allotted to the minimal land system were placed in a feedlot and fed a high grain diet (Table 1) after a 188-d backgrounding period on hay. In yr 2 and 3, calves allotted to the minimal land system were placed directly in a feedlot and finished on the high grain diet. Weaned calves allotted to the year-round grazing systems were placed in a drylot and fed hay throughout the winter to achieve a rate of gain of approximately .2 kg/d over 185 d. After winter, yearlings in the year-round grazing systems grazed with cows and calves for 98, 101, and 91 d in yr 1, 2, and 3 until early August when they were placed in a drylot and fed the high grain diet. Calves and yearlings were weighed unshrunk monthly until slaughter at a backfat of 1.0 cm, as determined by ultrasound image analysis. Finished cattle were slaughtered at a commercial packing plant and carcass weight was measured, ribeye area and backfat thickness was

Table 1. Composition of diet fed to minimal land and year-round grazing system animals in feedlot

Item	Concentration (%DM)
Corn	77.4
Haylage	18.8
Soybean Meal	3.7
41% commercial protein supplement	2.2
Rumensin/vitamin supplement	0.6
Calcium	0.5
Urea	0.3

measured by tracing a ribbed section onto acetate paper, and kidney, heart, and pelvic fat, marbling score, quality grade, and yield grade were estimated by a USDA meat evaluator. Because of the confounding management of minimal land and year-round animals in yr 1, only data from yr 2 and 3 was utilized in the analysis of the feedlot and carcass data.

Forage Sample Collection

To determine herbage mass and chemical composition, forage from smooth bromegrass-orchardgrass-birdsfoot trefoil pastures was collected monthly, and forages from tall fescue-red clover and smooth bromegrass-red clover pastures was sampled at the initiation, middle, and end of grazing these pastures. Forage samples were obtained by hand-clipping twelve .25-m^2 areas per pasture at a height of approximately 2 cm. Herbage density also was estimated by measurement of sward height with a falling plate meter (4.8 kg/m^2) in two locations when cows were moved into each paddock, and monthly means of these sward heights were calculated. Samples that were used to determine monthly yield and chemical composition began in April because summer grazing started at near the end of April. Sward height determination began in May; the first month that sward height was averaged. To determine botanical composition, forage samples were hand-clipped at approximately 2 cm from twelve .25-m^2 areas in the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures at the initiation and termination of summer grazing and twelve .25-m^2 areas in the tall fescue-red clover and smooth bromegrass-red clover pastures in late May and September of each year.

To determine yield and chemical composition of hay harvested, each bale was weighed at harvest and six bales from each pasture were randomly selected and core-sampled at two locations on opposite sides of the bales. Hay was stored outside on the ground for use in winter feeding systems (Hersom et al., 2000).

Chemical Analyses

Dry matter concentrations of hand-clipped forages and core-sampled hay were determined by drying at 65°C for 48 h in a forced air oven. All forage samples were ground with a Wiley mill to pass through a 1-mm screen. In vitro DM disappearance of all forage samples was determined by the procedure of Tilley and Terry (1963), as modified by Marten and Barnes (1980) for use of the NC-64 buffer and filtration on filter paper. Inoculum for IVDMD determination was obtained from a ruminally fistulated steer fed alfalfa hay and strained through four layers of cheesecloth. Dried forage samples also were analyzed for Kjeldahl N, using a selenium catalyst (AOAC, 1990) and NDF (Van Soest and Robertson, 1979), and ADF (Goering and Van Soest, 1970) using an ANKOM Fiber Analyzer 2000 (ANKOM Co., Turk Hill, NY).

Statistical Analyses

Monthly herbage masses, sward heights, chemical compositions, and forage allowances of forages from smooth bromegrass-orchardgrass-birdsfoot trefoil, tall fescue-red clover, and smooth bromegrass-red clover pastures were analyzed by month using the GLM procedure (SAS, 1988) for a split-plot design with main effects of year and forage species and the interaction of year and species. The significance of differences between means of variables with significant forage species effects was determined using t-tests. Botanical compositions of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures was analyzed by the GLM procedure (SAS, 1988) as a split-plot design with a model including the main effects of management system, season, and year and the interactions of system by season, system by year, season by year, and the three-way interaction of system, season, and year. Botanical composition of tall fescue-red clover and smooth bromegrass-red clover was analyzed as a split-plot design described in a companion paper (Hersom et al., 2000). Summer hay production and composition was analyzed by the GLM procedure (SAS, 1988) for a randomized design with the main effects of year and forage species and the two-way interaction of year and forage species. Cow BW, body condition score, calving interval, rebreeding rate, calf and yearling growth, and winter forage production were analyzed by ANOVA (SAS, 1988) for a randomized design with main effects of year and management system and the two-way interaction of year and management system. The significance of differences between means of forage grazing systems was determined using t-tests with significance declared at $P < .05$. Feed DM intake and carcass characteristics of cattle finished in feedlots were analyzed by ANOVA (SAS, 1988) for a randomized design utilizing years as replicates.

Results

Weather

Mean monthly temperatures were 1.6 and 1.3 ^{o}C below the 46-yr average (1951-1997) during summer grazing in yr 1 and 2, respectively (NOAA, 1996; NOAA, 1997; Hersom et al., 2000). In yr 3, mean monthly temperatures were 1.7, .4, and 2.1 ^{o}C above average in May, August, and September, respectively (NOAA, 1998). In yr 1 and 2, monthly precipitation was 4.3 and 2.4 cm below average in April when early spring growth would begin to occur (Hersom et al., 2000). Conversely during May in yr 1,2, and 3, precipitation was 15.7, 2.3, and 7.7 cm above the 46-yr average. During yr 1, precipitation was 3.0 and

7.3 cm below average in June and July, possibly limiting midsummer forage production. In yr 3, precipitation in June was 6.2 cm above the 46-yr average, making hay harvest difficult.

Botanical Composition

Because mean proportions of live DM and the concentrations of grass, legume, and broadleaf weed species in the live DM of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures were not different ($P > .10$) between forage management systems, pooled means of year and season are presented (Table 2). But, the proportion of legume in the live DM of pastures in the Minimal land system was 6.1% units lower ($P < .01$) than smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the Year-round grazing system. The proportion of total forage DM that was live decreased by 12.8% units from spring to fall in yr 1, but increased by 29.3 and 40.2% units from spring to fall in yr 2 and 3 (s x yr, $P < .01$). The proportion of grass in the live forage DM was greater ($P = .06$) in the fall of each year than in the spring. The proportion of grass was lower in the spring and higher in the fall of yr 2 than in either yr 1 or 3 (s x yr, $P = .02$). Conversely, the proportion of legumes in the live DM was greater in the spring than in the fall in yr 1 and 2, but not in yr 3 (s x yr, $P < .01$). The proportion of broadleaf weeds in the fall increased by 1.8, 8.6, and 1.7 % units from spring to fall in yr 1, 2, and 3, repectively (s x yr, $P = .04$).

As described in a companion paper (Hersom et al., 2000), the mean proportion of legumes in the live DM of tall fescue-red clover pastures decreased from 23.6 to 14.2 % of the live DM, while that in smooth bromegrass-red clover pastures decreased from 16.4 to 14.1% of the live DM over the 3-yr experiment.

Table 2. Mean botanical composition of summer smooth bromegrass-orchardgrass-birdsfoot trefoil forages in both spring and fall of 3 yr

	Season (s) and year (yr)							Significance		
	Spring			Fall						
Item and year	1996	1997	1998	1996	1997	1998	SEM [a]	s	yr	s * yr
% live DM	52.1	51.9	39.3	39.3	81.2	79.5	1.17	<.01	<.01	<.01
% of live DM										
Grass	82.2	69.2	82.7	82.7	84.5	83.9	1.71	.06	.04	.02
Legume	10.2	24.7	1.1	1.1	1.9	5.0	.96	<.01	<.01	<.01
Weed	7.6	6.2	9.4	9.4	14.7	11.1	.72	NS	NS	.04

[a] Standard error of measurement, n = 8.

Herbage Masses and Chemical Composition

At initiation of summer grazing, 3-yr average DM herbage masses of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures were 1,323, 1,205, and 1,306 kg/ha for the year-round grazing system with mid-summer tall fescue-red clover, year-round grazing system with mid-summer smooth bromegrass-red clover, and minimal land system, respectively (Figure 1). In June, smooth bromegrass-orchardgrass-birdsfoot trefoil pastures grazed by yearlings in the year-round grazing systems had greater herbage masses ($P < .05$) than smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land system and the smooth bromegrass-red clover pastures grazed by cows in the year-round grazing system with mid-summer smooth bromegrass-red clover. Tall fescue-red clover and smooth bromegrass-red clover herbage masses in June were high because of the effect of grazing more mature first cutting forage in yr 1 on 25% of the area of these pastures. Tall fescue-red clover and smooth bromegrass-red clover herbage masses decreased thereafter in July and August because cow-calf pairs were grazing second cutting regrowth in all 3 yr. During July, smooth bromegrass-orchardgrass-birdsfoot trefoil pastures grazed by yearlings in the year-round grazing system had greater ($P < .05$) herbage masses than smooth bromegrass-orchardgrass-birdsfoot trefoil in the minimal land system, which had greater ($P < .05$) herbage masses than the second harvest in either the tall fescue-red clover or smooth bromegrass-red clover pastures grazed by cows and calves in the year-round grazing system. During August, herbage masses of the tall fescue-red clover and smooth bromegrass-red clover pastures at the termination of grazing by cows and calves in the year-round grazing system were less ($P < .05$) than smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in either the minimal land system or year-round grazing system with midsummer grazing of tall

Figure 1. Three-year mean of monthly herbage DM yield of summer pastures.

	April	May	June	July	August	September	October
SEM	46.7	125.8	85.1	71.9	65.6	82.8	113.4

	n
YR/TF-RC SB-OG-BT	2
YR/SB-RC SB-OG-BT	2
ML SB-OG-BT	4
YR TF-RC	2
YR SB-RC	2

[a,b,c] Means with different superscripts are significantly different $P < .05$.

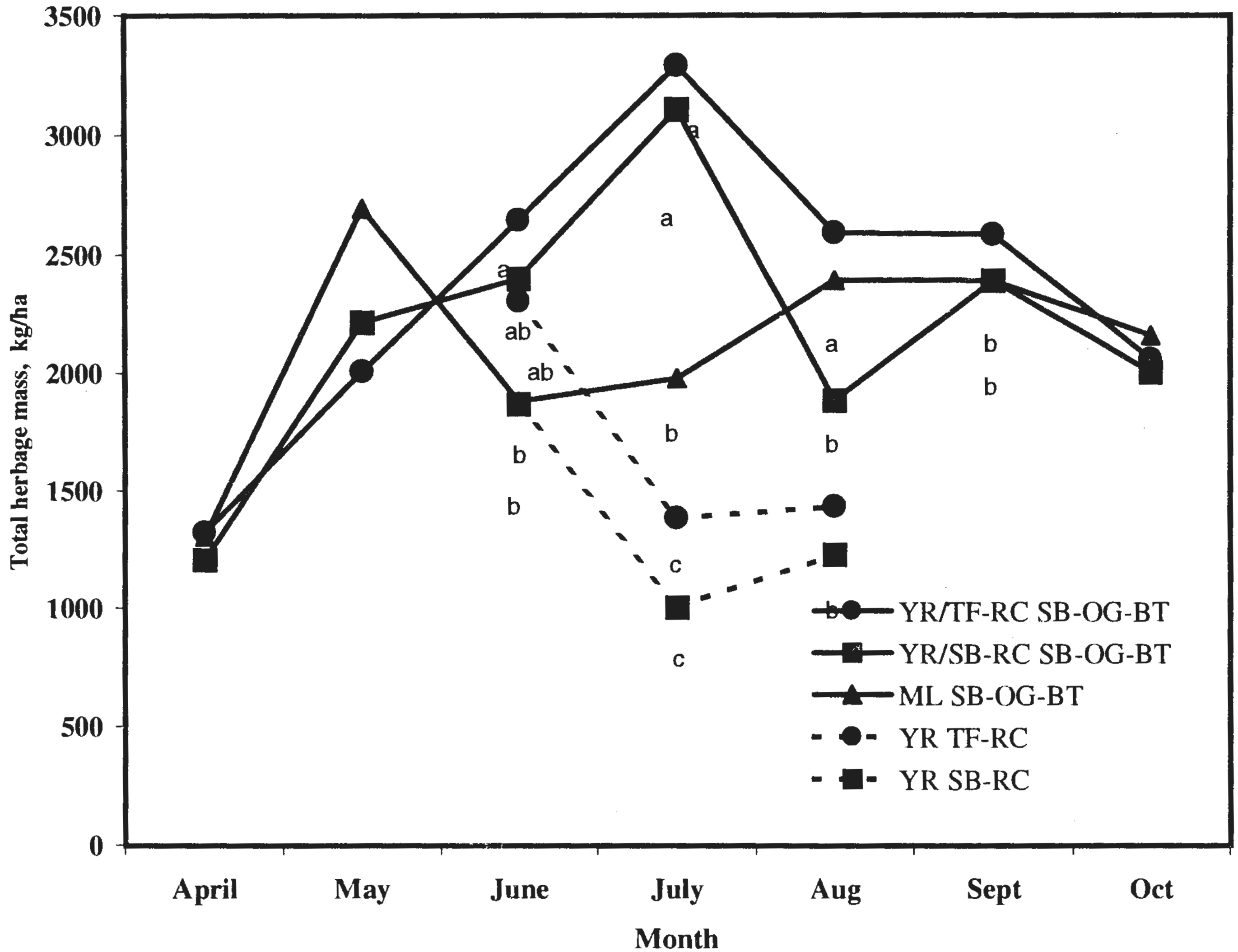

Figure 1. (continued)

fescue-red clover pastures. In September and October, herbage masses of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures were 2,455 and 2,072 kg/ha and did not differ between management systems.

At the initiation of summer grazing of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures, 3 yr mean forage allowances (9.43 kg herbage DM/100 kg BW) were not different (Figure 2). In June, smooth bromegrass-orchardgrass-birdsfoot trefoil in the year-round grazing system with mid-summer tall fescue-red clover had greater ($P < .05$) forage allowances (22.12 kg herbage DM/100 kg BW) than smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land grazing system and smooth bromegrass-red clover pastures (14.16 and 13.25 kg herbage DM/100 kg of BW). In August, forage allowances from smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the year-round grazing systems (25.66 kg herbage DM/100 kg of BW) were greater ($P < .05$) than those of tall fescue-red clover (15.68 kg herbage DM/100 kg of BW), smooth bromegrass-red clover (12.48 kg herbage DM/100 kg of BW), and smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land grazing system clover (10.67 kg herbage DM/100 kg of BW). In October, mean forage allowances of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures (8.56 kg herbage DM/100 kg BW) did not differ ($P > .10$) between grazing systems. Marsh et al. (1979) indicated that if the forage allowance dropped below 10-kg forage/100 kg BW, animal performance would be expected to drop. But the Nutrient Requirements of Beef Cattle (NRC, 1996) suggested a level of 5 kg forage/100 kg BW was the threshold at which intake of grazed forage was decreased due to decreasing forage allowance.

Mean sward heights of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures, at grazing initiation (12.6 cm) and in June (15.3 cm) measured with a falling plate meter, did

Figure 2. Three-year mean forage allowance of smooth bromegrass-orchardgrass-birdsfoot trefoil, tall fescue-red clover, and smooth bromegrass-red clover pastures.

	May	June	August	October
SEM	.42	.87	.59	.31

	n
YR/TF-RC SB-OG-BT	2
YR/SB-RC SB-OG-BT	2
ML SB-OG-BT	4
YR TF-RC	2
YR SB-RC	2

[a,b,c] Means with different superscripts are significantly different $P < .05$.

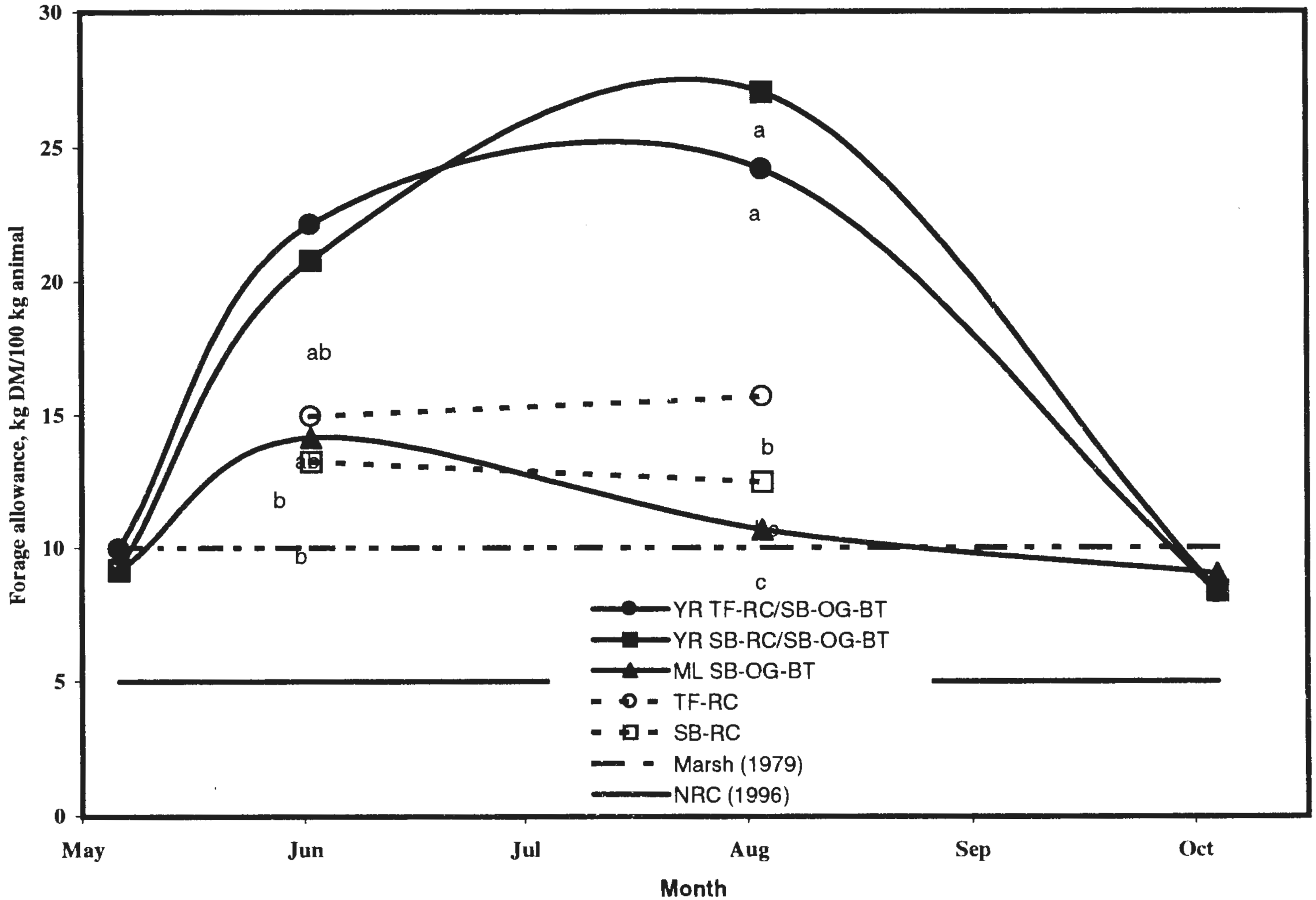

Figure 2. (continued)

not differ ($P > .05$) between management systems (Figure 3). Although hay was harvested from both the tall fescue-red clover and smooth bromegrass-red clover pastures before they were grazed, the sward heights of the tall fescue-red clover pastures (21.2 cm) were greater ($P < .05$) than the smooth bromegrass-red clover pastures (12.7 cm) in June. Presumably, these high sward heights were caused by grazing first cutting forage on 25% of the land area in yr 1. During July, sward heights of the smooth bromegrass-red clover (8.9 cm) and tall fescue-red clover (7.5 cm) pastures grazed by cows in the year-round grazing systems and smooth bromegrass-orchardgrass-birdsfoot trefoil (10.3 cm) pastures grazed by cows in the minimal land system were lower ($P < .05$) than forage in the smooth bromegrass-orchardgrass-birdsfoot trefoil (15.1 cm) pastures grazed by yearlings in the year-round grazing systems. In August, sward heights of tall fescue-red clover and smooth bromegrass-red clover at the termination of their summer grazing (8.4 cm) were lower ($P < .05$) than the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in either forage management system (13.6 cm). Furthermore, when cows in the year-round grazing systems returned to graze smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in August, sward heights of the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the year-round grazing system with midsummer tall fescue-red clover (16.3 cm) were greater ($P < .05$) than smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land system (11.0 cm). Sward heights of the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures were 11.0 and 6.1 cm in September and October and did not differ ($P < .10$) between forage management systems.

Over 3 yr, mean initial IVDMD concentration of smooth bromegrass-orchardgrass-birdsfoot trefoil pastures was 56.6 % and did not differ ($P > .10$) between forage management

Figure 3. Three-year mean monthly forage sward height of summer pastures.

	May	June	July	August	September	October
SEM	.26	.50	.34	.34	.30	.15

	n
YR/TF-RC SB-OG-BT	2
YR/SB-RC SB-OG-BT	2
ML SB-OG-BT	4
YR TF-RC	2
YR SB-RC	2

[a,b,c] Means with different superscripts are significantly different $P < .05$.

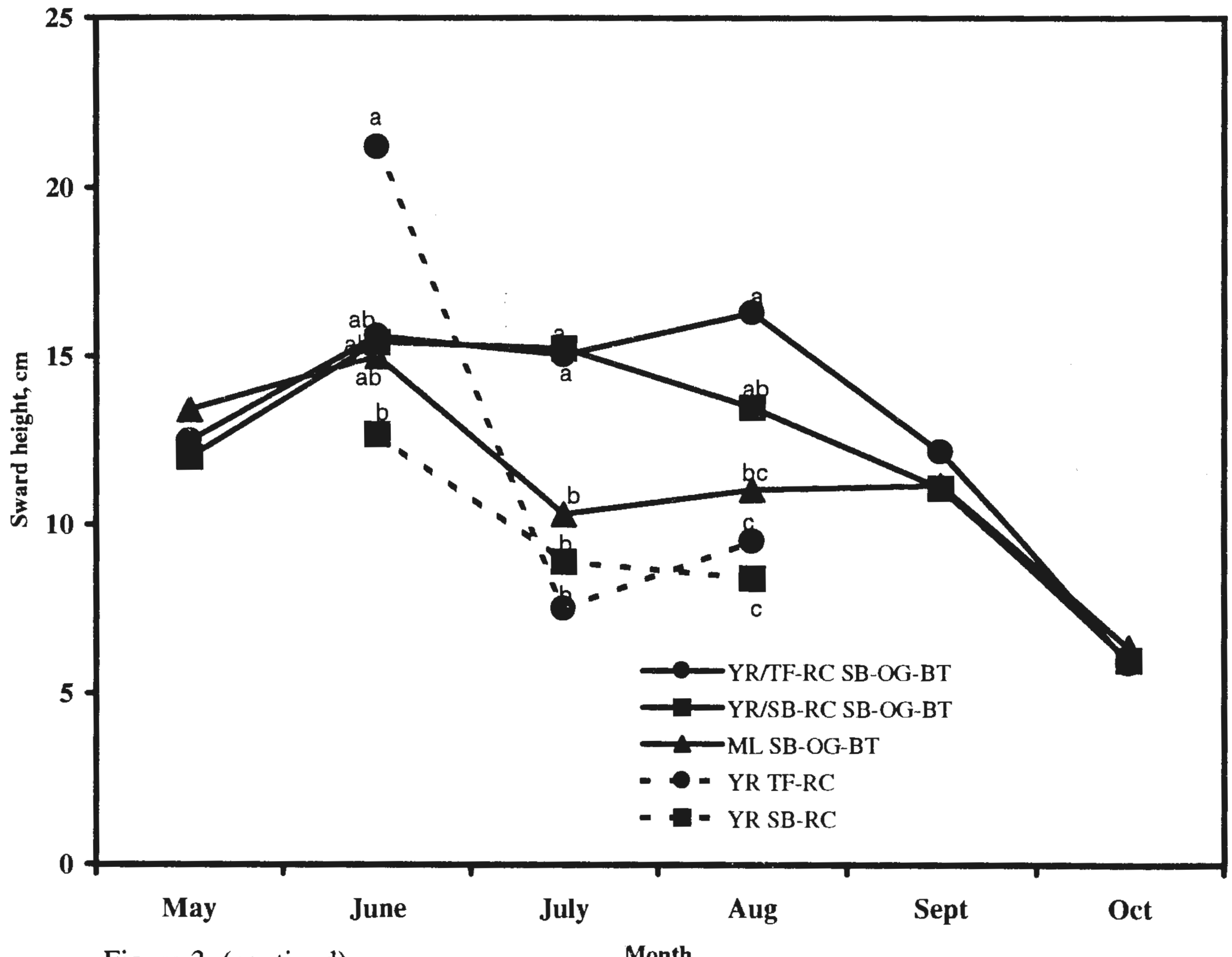

Figure 3. (contined)

systems (Figure 4). In May, IVDMD concentrations of the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the year-round grazing system with midsummer tall fescue-red clover, year-round grazing system with mid-summer smooth bromegrass-red clover, and minimal land system increased to 61.2, 66.1, and 57.6% ($P < .05$). In June, IVDMD concentrations of tall fescue-red clover (58.6%) and smooth bromegrass-red clover (58.3%) pastures grazed by cows and calves in the year-round grazing systems were significantly lower ($P < .05$) than the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures (67.8 and 66.8%) grazed by cows and calves in the minimal land system and yearlings in the year-round grazing system with midseason smooth bromegrass-red clover grazing. Mean IVDMD concentrations of smooth bromegrass-orchardgrass-birdsfoot trefoil, tall fescue-red clover and smooth bromegrass-red clover pastures were 63.8, 61.9, and 63.2% in July, respectively. Tall fescue-red clover and smooth bromegrass-red clover IVDMD concentrations in June were reduced because the effects of grazing more mature first cutting forage in yr 1. Tall fescue-red clover and smooth bromegrass-red clover IVDMD concentrations increased thereafter in July and August because cow-calf pairs were grazing second cutting regrowth in all 3-yr. Mean IVDMD concentrations of smooth bromegrass-orchardgrass-birdsfoot trefoil in the year-round grazing systems with midsummer tall fescue-red clover (64.1%) or smooth bromegrass-red clover (64.2%) were greater ($P < .05$) than tall fescue-red clover (53.4%) or smooth bromegrass-red clover (52.6%) forages. During September and October, mean IVDMD concentrations (64.8 and 66.6%) of smooth bromegrass-orchardgrass-birdsfoot trefoil forages did not differ between grazing systems ($P > .10$).

Crude protein concentrations of forage in smooth bromegrass-orchardgrass-birdsfoot trefoil pastures at the initiation of grazing (15.7%) did not differ ($P > .10$) between forage

Figure 4. Three-year mean IVDMD concentrations of summer pastures.

	April	May	June	July	August	September	October
SEM	.68	.54	.73	.51	.87	1.61	1.0

	n
YR/TF-RC SB-OG-BT	2
YR/SB-RC SB-OG-BT	2
ML SB-OG-BT	4
YR TF-RC	2
YR SB-RC	2

[a,b,c] Means with different superscripts are significantly different $P < .05$.

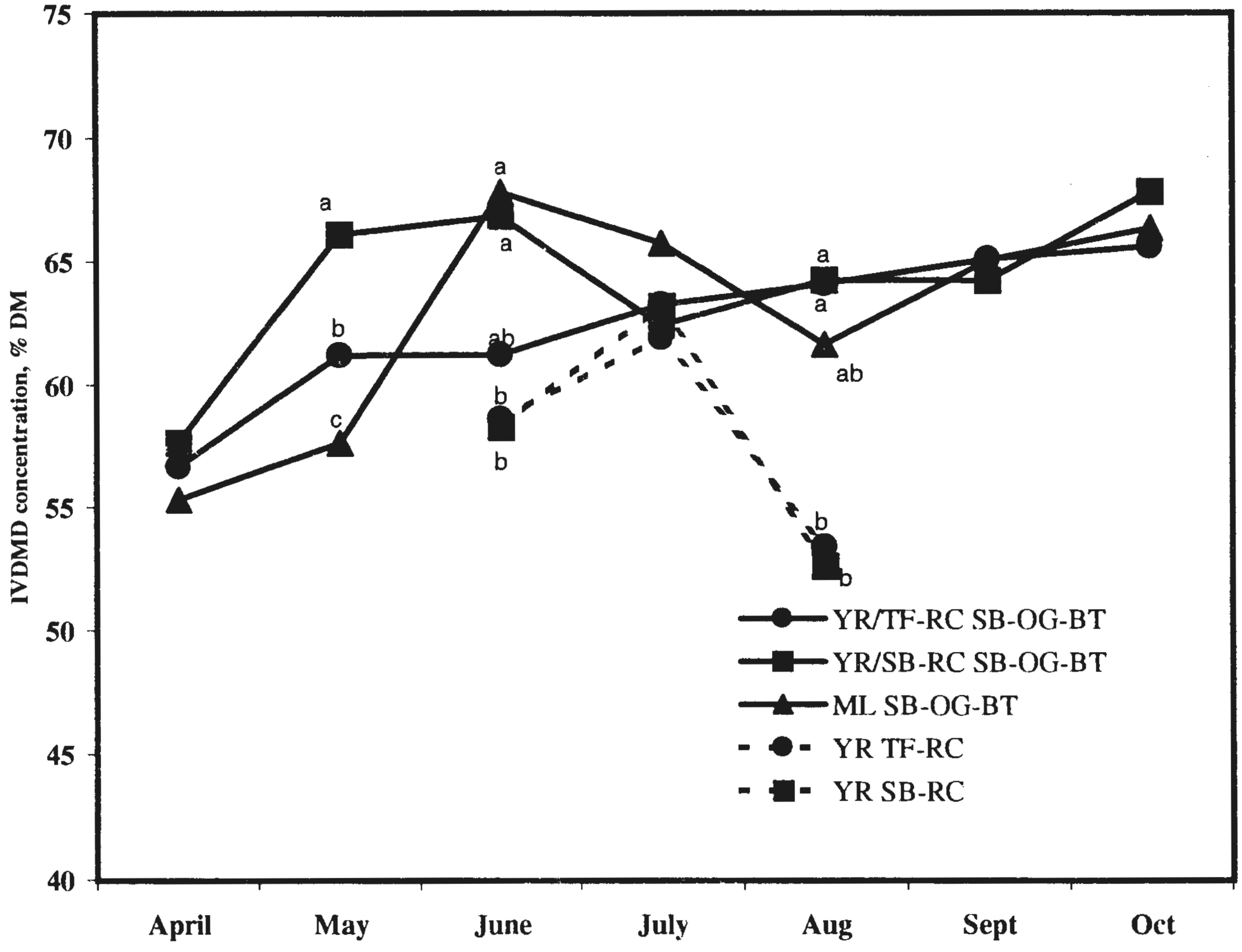

Figure 4. (continued)

management systems (Figure 5). Similarly, CP concentrations of forage in smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in May (12.3%), July (13.3%), August (13.5%), September (12.9%), and October (12.0%) were not affected by grazing management. In June, however, the CP concentration of forage in smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the Year-round grazing systems was greater ($P < .05$) than smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the Minimal land system. Crude protein concentrations of the forages in the tall fescue-red clover (12.6%) and smooth bromegrass-red clover pastures (11.3%) were greater ($P < .05$) than smooth bromegrass-orchardgrass-birdsfoot trefoil (10.35%) in the Minimal land system. Mean CP concentrations did not differ ($P > .10$) between forages during July, August, September, or October (13.0, 13.3, 12.9, and 12.0% respectively).

Concentrations of NDF in pasture forages did not differ ($P > .10$) between forage species and management system in any month during the grazing season. Concentrations of NDF in smooth bromegrass-orchardgrass-birdsfoot trefoil pastures increased from 48.0% at the initiation of grazing to a mean of 56.9 $\pm$ 1.0% in May to October. Mean ADF concentrations of forage in smooth bromegrass-orchardgrass-birdsfoot trefoil pastures at the initiation of grazing and in May were 28.8 and 37.3% and did not differ ($P > .10$) between forage management systems. In June and July, however, ADF concentrations of forage in the tall fescue-red clover (39.0 and 38.4%) and smooth bromegrass-red clover (37.2 and 38.2%) pastures grazed by cows in the year-round grazing systems and in the smooth bromegrass-orchardgrass-birdsfoot trefoil (38.0 and 37.4%) pastures grazed by cows in the minimal land system were greater ($P < .05$) than the smooth bromegrass-orchardgrass-birdsfoot trefoil (33.3 and 31.3%) pastures grazed by yearlings in the year-round grazing

Figure 5. Three-year mean CP concentration of summer pastures.

	April	May	June	July	August	September	October
SEM	.42	.35	.19	.29	.34	.22	.48

	n
YR/TF-RC SB-OG-BT	2
YR/SB-RC SB-OG-BT	2
ML SB-OG-BT	4
YR TF-RC	2
YR SB-RC	2

[a,b,c] Means with different superscripts are significantly different $P < .05$.

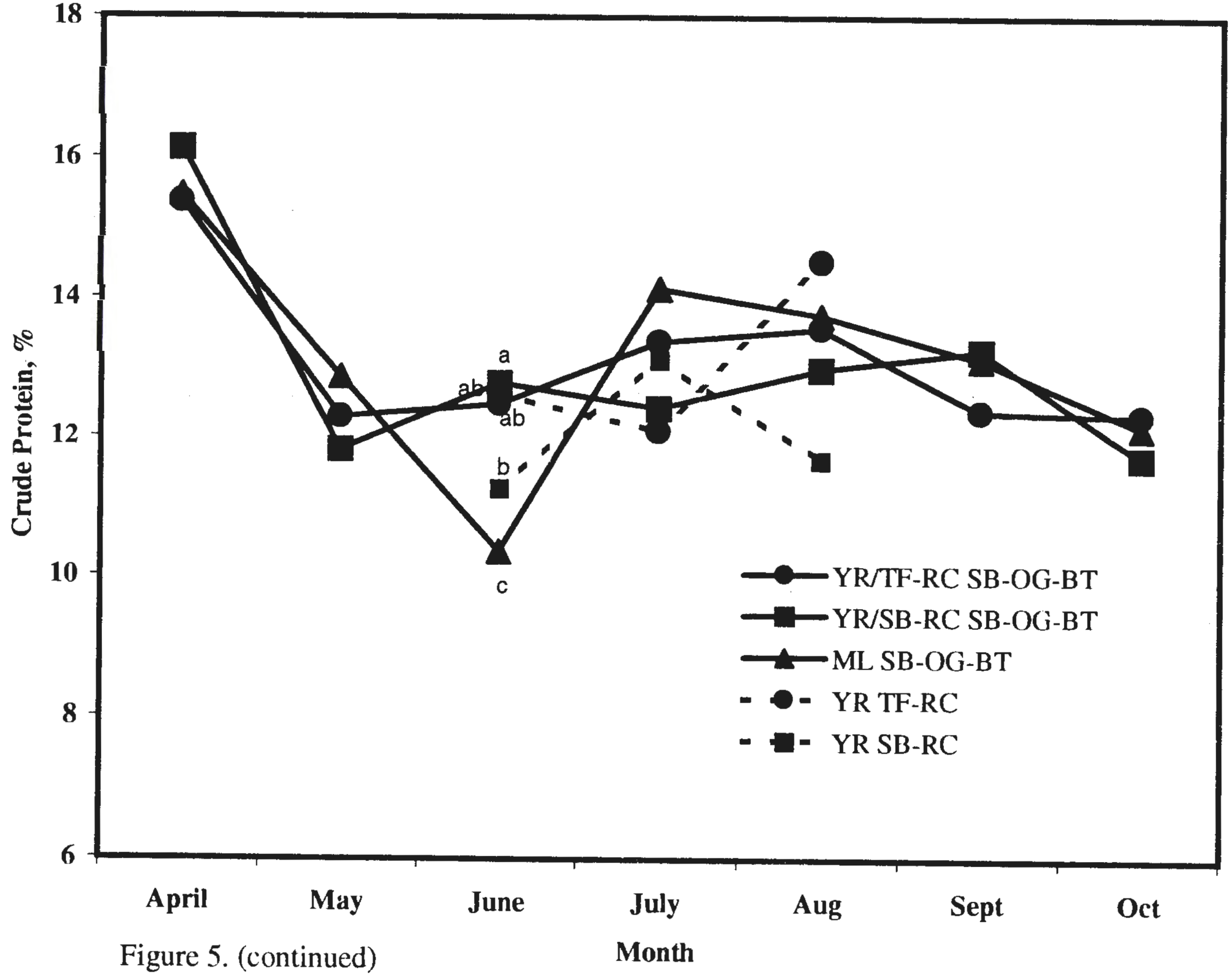

Figure 5. (continued)

system. In contrast, ADF concentration of forage in smooth bromegrass-red clover pastures grazed by cows in the year-round grazing system in August (34.6%) was lower (*P* < .05) than smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in either the minimal land (36.0%) or year-round grazing (36.7%) systems. In September and October, ADF concentrations of forages in smooth bromegrass-orchardgrass-birdsfoot trefoil pastures grazed by cows in both management systems were 38.4 and 38.2% and did not differ (*P* > .10) between management systems.

Cow BW, Condition Scores, and Rebreeding Rates

Over the 3 yr, there were no differences (*P* > .10) in the initial neither BW nor condition score as a result of previous winter management (Figure 6; Hersom et al., 2000). Similarly, there were no differences in the seasonal changes in cow BW and condition score. Body weight increases during the breeding season from mid-June to August were greater (*P* < .05) for cows grazing second harvest smooth bromegrass-red clover in the ear-round grazing system than cows grazing smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land system. But breeding season BW increases of cows grazing second harvest tall fescue-red clover in the year-round grazing system did not differ from either of the other systems. During the postbreeding season from August to November cows grazing smooth bromegrass-orchardgrass-birdsfoot trefoil in the minimal land system gained more (*P* < .05) BW than cows that grazed smooth bromegrass-red clover pastures in midsummer in the year-round grazing system, but did not differ from those grazing tall fescue-red clover pastures in midsummer. Over the 3 yr, mean rebreeding rates and calving intervals were 94.7% and 375 d for cows in the Minimal land system, Year-round grazing system with mid-summer tall fescue-red clover, and Year-round grazing system with mid-summer smooth

Figure 6. Three-year mean body weight and condition score of cows at the initiation, initiation of breeding, postbreeding, and termination of summer grazing.

	SEM (n = 8)	
	Body Weight	Condition Score
Initiation	4.2	.10
Prebreeding	1.8	.09
Breeding	1.0	.10
Postbreeding	2.0	.12

[a,b,c] Means with different superscripts are significantly different $P < .05$.

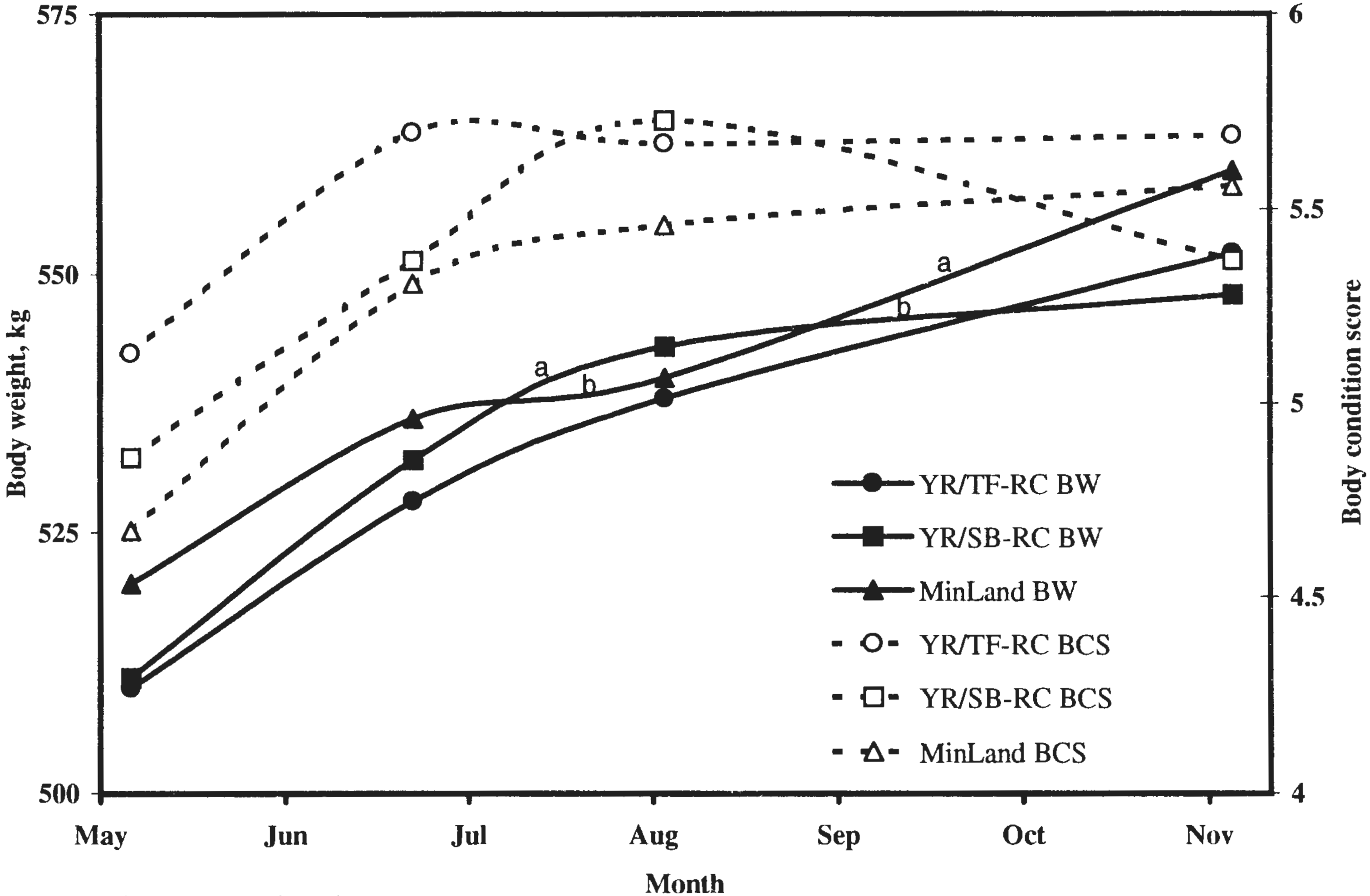

Figure 6. (continued)

bromegrass-red clover and did not differ between management systems. Calving intervals longer than 365 coupled with the high rebreeding rates would imply that more cows were being bred during the last 21 d of the breeding season. In yr 2 this effect was caused by delaying the breeding period by 14 d compared to yr 1. Reasons for the extended calving interval in yr 3 have no apparent reason. Zalesky et al (1984) and Stumpf et al. (1992) both indicated a delay in the return to estrous when cows were not exposed to bull during the 45-53 d postpartum

Calf and Growing Animal Production

The mean ADG of calves from the minimal land system (1.04 kg/d) did not differ ($P > .05$) from calves in the year-round grazing system with midsummer tall fescue-red clover (1.03 kg/d), but was greater ($P < .05$) than calves in the year-round grazing system with midsummer smooth bromegrass-red clover (.96 kg/d; Table 3). These relationships were primarily caused by differences between treatments in yr 3, when they also were significant. Inasmuch as cows were reallotted between systems at the initiation of winter grazing in each year of the experiment, it is unlikely that the lower ADG of calves grazing in the year-round grazing system with midsummer smooth bromegrass-red clover was caused by the milk production capacity of the cows or growth potential of calves. Therefore, the lower ADG of calves grazing in this system seems caused by the low herbage mass of the second harvest smooth bromegrass-red clover pasture grazed by cows and calves in the Year-round grazing system during midsummer, the low CP of the second harvest smooth bromegrass-red clover pasture grazed by cows and calves in the year-round grazing system during mid-summer, and/or the low herbage mass of the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures grazed by these cows in August. The ADG of yearling cattle grazing smooth

Table 3. Annual growing animal production during summer grazing from three summer forage systems

Item and year	Forage systems: Minimal land	Year-round / TF-RC	Year-round / SB-RC	SEM [a]
Daily gain, kg/d				
Calf				
1996	1.03	1.02	.98	.01
1997	1.05	1.06	.97	.03
1998	1.05[b]	1.02[bc]	.93[c]	.02
Avg.	1.04[b]	1.03[bc]	.96[c]	.01
Yearling				
1996	-	.87	.85	.01
1997	-	1.22	1.01	.02
1998	-	.99	1.09	.01
Avg.	-	1.03	.98	.07
Seasonal gain, kg/ha [d]				
Calf				
1996	187.8[b]	92.8[c]	88.5[c]	1.05
1997	193.7[b]	96.7[c]	88.9[c]	3.30
1998	197.2[b]	96.1[c]	87.5[c]	2.32
Avg.	192.9[b]	95.2[c]	88.3[c]	1.68
Yearling				
1996	-	42.3	41.9	.40
1997	-	45.1	42.4	.66
1998	-	53.4	48.6	.36
Avg.	-	46.9	44.3	1.0
Growing animal [e,f]				
1996	187.8[b]	135.1[c]	130.4[c]	1.08
1997	193.7[b]	141.8[c]	131.3[c]	3.16
1998	197.2[b]	149.5[c]	136.1[c]	2.37
Avg.	192.9[b]	142.1[c]	132.6[c]	1.63

[a] SEM n = 8.
[b, c] Means within a year with different superscripts are significantly different $P < .05$.
[d] Land area of the minimal land and year-round grazing systems were 4.05 and 10.12 ha/cow-calf pair.
[e] Production of calves in the minimal land system and calves and yearlings in the year-round grazing systems.
[f] Utilizing mean hay yields during the 3 yr .47 ha/cow of additional land for hay production would be required to meet the hay
needs of minimal land system cows, resulting in growing animal seasonal production of 130 kg/ha.

bromegrass-orchardgrass-birdsfoot trefoil pastures for 91 to 99 d was 1.01 kg/d and did not differ between year-round grazing systems. In contrast to ADG, seasonal calf production of the minimal land system, expressed as kilogram BW gain per hectare, was significantly greater ($P < .05$) than either year-round grazing system in each year of the experiment. This difference primarily resulted from differences in the land areas of perennial forages used for the minimal land (4.05 ha) and year-round grazing (10.12 ha) systems. Similar to ADG, seasonal production of yearling gains (mean = 45.6 kg/ha) did not differ ($P > .10$) between year-round grazing systems. In spite of the addition of yearling gains to those of calves in the year-round grazing systems, total growing animal production was greater ($P < .05$) for the minimal land system than for either year-round grazing system.

Hay Production and Chemical Composition

Over 3 yr, mean hay production per system was greater ($P < .05$) from the tall fescue-red clover (10,377 kg DM) and smooth bromegrass-red clover (11,919 kg DM) pastures in the year-round grazing systems than from the smooth bromegrass-orchardgrass-birdsfoot trefoil (4,360 kg DM) pastures in the minimal land system (Table 4). Because of differences in the land areas in the total systems and those from which hay is harvested, average hay production from the land area harvested did not differ ($P > .10$) between systems over 3 yr. The lack of difference in hay yields in each year seems to imply that grazing early spring forage in the tall fescue-red clover or smooth bromegrass-red clover pastures until May had no greater adverse effects than annual summer hay harvest and grazing of the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures. Over 3 yr, mean hay production per cow from the tall fescue-red clover (2,075 kg) and smooth bromegrass-red clover (2,384 kg) pastures in the year-round grazing systems were greater ($P < .05$) than the smooth

Table 4. Summer hay production from minimal land smooth bromegrass-orchardgrass-birdsfoot trefoil, year-round tall fescue-red clover, or year-round smooth bromegrass-red clover pastures

Item and year	Forage systems			SEM [a]
	Minimal land	Year-round / TF-RC	Year-round / SB-RC	
Gross hay, kg DM/system [b]				
1996	4,937[f]	11,448[g]	11,761[g]	325
1997	4,588[f]	8,787[g]	10,122[g]	296
1998	3,556[f]	10,895[g]	13,875[g]	1,158
Avg.	4,360[f]	10,377[g]	11,919[g]	505
Harvested hectares, kg DM/ha [c]				
1996	3,248[f]	2,511[g]	2,579[g]	194
1997	2,265	1,448	1,668	166
1998	1,756	1,795	2,286	355
Avg.	2,423	1,918	2,178	219
Hay kg DM/cow [d]				
1996	1,234[f]	2,290[g]	2,352[g]	72
1997	1,147[f]	1,757[g]	2,024[g]	74
1998	889[f]	2,179[g]	2,775[g]	290
Avg.	1,090[f]	2,075[g]	2,384[g]	124
Net winter forage, kg DM/cow [e]				
1996	1,234[f]	4,663[g]	4,907[g]	93
1997	1,147[f]	5,712[g]	4,997[g]	2
1998	889[f]	7,379[g]	7,281[g]	171
Avg.	1,090[f]	5,918[g]	5,728[g]	123

[a] SEM, n = 8.

[b] Total system, minimal land = 4.05 ha, year-round systems = 10.12 ha.

[c] Harvested ha, minimal land 1996 = 1.52 ha, 1997 and 1998 = 2.025 ha, year-round systems 1996 = 4.56 ha, 1997 and 1998 = 6.07 ha.

[d] Minimal land and year-round grazing systems had 1.01 and 2.02 ha perennial forage per cow.

[e] Net winter forage = hay kg DM/cow + stockpiled forage kg DM/cow.

[f, g] Means within year with different superscripts are significantly different $P < .05$.

bromegrass-orchardgrass-birdsfoot trefoil (1,090 kg) in the minimal land system. Similarly, because of stockpiled forage production in the year-round grazing systems, mean net winter forage production from the year-round grazing systems with midsummer grazing of tall fescue-red clover (5,918 kg/cow) or smooth bromegrass-red clover (5,728 kg/cow) pastures was greater ($P < .05$) than the minimal land system (1,090 kg/cow).

At harvest, IVDMD concentrations of smooth bromegrass-red clover (56.1%) and tall fescue-red clover (55.8%) hays were greater ($P = .04$) than smooth bromegrass-orchardgrass-birdsfoot trefoil (53.0 %) hay over 3 yr (Table 5). Similarly, CP concentrations were higher ($P = .01$), and NDF ($P = .05$) and ADF ($P = .01$) concentrations were lower in tall fescue-red clover and smooth bromegrass-red clover hays than in smooth bromegrass-orchardgrass-birdsfoot trefoil hay over 3 yr. Because weather delayed harvest in yr 1 until July 1 and rain damaged hay before baling in yr 3, IVDMD concentrations of hays in yr 2 (64.7%) were greater ($P < .01$) than in yr 1 (57.3 %) or 3 (41.1%). Similarly, these conditions seemingly resulted in mean concentrations of NDF and ADF in the hays that were lower ($P < .01$) in yr 2 than in yr 1 and 3.

Feedlot Cattle Performance and Carcass Characteristics

Because ADG of calves from the year-round grazing system was .19 kg/d while backgrounded on hay during winter and 1.0 kg while grazing pastures during summer, feedlot cattle required 84 fewer ($P < .10$) days to achieve a comparable backfat thickness to cattle placed directly into the feedlot in the minimal land system (Table 6). Because of the hay fed to calves while backgrounded in winter, the amounts of hay consumed per calf in the year-round grazing system for cows (1,438 kg DM) were greater ($P < .05$) than for cattle in the minimal land system (729 kg DM). In spite of these effects, neither the feedlot ADG,

Table 5. Three-year hay chemical composition at harvest of smooth bromegrass-orchardgrass, tall fescue-red clover, and smooth bromegrass-red clover forages

Forage species (s) and year (y)	Chemical composition, % DM			
	IVDMD	CP	NDF	ADF
Smooth bromegrass-orchardgrass-birdsfoot trefoil				
1996	54.1	9.9	62.8	35.1
1997	65.2	12.0	56.5	36.4
1998	39.7	10.9	68.0	46.4
Tall fescue-red clover				
1996	62.0	14.0	56.0	33.0
1997	63.4	13.2	55.8	33.3
1998	42.0	11.9	65.7	44.0
Smooth bromegrass-red clover				
1996	60.6	11.6	59.8	33.9
1997	64.8	11.2	58.4	33.4
1998	43.0	13.3	68.9	40.9
SEM [a]	.50	.23	.50	.39
Significance				
f	.04	.01	.05	.01
yr	<.01	NS	<.01	<.01
yr * f	.05	.04	NS	NS

[a] SEM, n = 24.

Table 6. Two-year mean of yearling feedlot performance and carcass characteristics of animals from minimal land and both year-round grazing systems

	Forage management system [a]		
Item	Minimal land	Year-round	SEM [b]
Days postweaning			
Backgrounding		185	2.0
Feedlot	229[h]	104[i]	8.8
Total	229[h]	289[i]	9.6
Hay, DM kg/animal [c]			
Backgrounding		1,124	17.3
Feedlot	308	268	31.2
Concentrates, DM kg/animal [d]	1,673	1,158	67.2
Efficiency of gain, DM kg concentrate/kg gain	4.87	3.79	.64
Efficiency of gain, total kg DM/kg gain	5.85	9.10	1.8
Average daily gain, kg/d [e]	1.37	1.53	.07
Hot carcass wt, kg	330	323	10.6
Marbling score [f, g]	1,050	1,048	7.4
Kidney-pelvic-heart fat [f]	2.53	1.75	.20
Back fat, mm	13.0	12.3	1.23
Ribeye area	13.9.	14.45	.45
Yield grade [f]	2.08	1.93	.08
% Choice [f]	84.5	77.5	1.5

[a] Minimal land animals placed directly into feedlot, year-round animals are both TF-RC and SB-RC animals placed in feedlot together after summer grazing.
[b] SEM, n = 4.
[c] Hay consumed during winter drylot maintenance by year-round animals in all years.
[d] Grain and protein consumed during finishing period.
[e] Average daily gain of time spent in feedlot during finishing period.
[f] Estimated by USDA carcass evaluators.
[g] 900 = slight, 1,000 = small, 1,100 = modest, 1,200 = moderate.
[h, i] Means with different superscripts are significantly different $P < .10$.

total amounts of concentrates fed per animal, nor carcass characteristics measured differed ($P > .10$) between calves produced by either of the two forage management systems. Although backgrounding of calves in the minimal land system on hay during winter of yr 1 may have confounded results, similar carcass characteristics, feed consumption, and feed efficiency were observed when minimal land system calves were placed in the feedlot immediately at weaning in yr 2 and 3. However, when yr 1 was eliminated from the data set, the feedlot ADG of animals in the minimal land (1.26 kg/d) was lower ($P < .05$) than the ADG of yearlings in the year-round system (1.95 kg/d). Additionally, minimal land system animals spent a greater ($P < .05$) amount of time, on feed (228 d) compared to 104 d for year-round grazing system animals.

Discussion

A high proportion of forage growth from cool-season forage species occurs during late spring and early summer (Anslow and Green, 1967; Corrall and Fenlon, 1978). As a result, use of set stocking rates during early summer can result in reductions in forage quality (Murphy et al., 1955). Therefore, control of excess forage produced early in the grazing season is imperative to manage forage for summer use.

Summer forage production from land used for stockpiling of forage for winter grazing adds to excess early summer forage production that already occurs in summer pastures (Allen et al., 1992, Hitz and Russell, 1998). Allen et al. (1992) utilized the land area used for winter grazing of stockpiled forages for hay harvest and creep grazing of calves. However, the use of grazing at a set stocking rate without hay harvest from summer pastures resulted in increased maturity and lower nutritional quality of pasture forage or inadequate forage availability in late summer (Allen et al., 1992). During the 3 yr of this experiment, quantity and quality of forage in the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures were controlled by either using hay harvest from a portion of the pastures in the minimal land system or using a modified put-and-take stocking system in the year-round grazing systems. In the minimal land system, the number of animals stayed constant, but the amount of land grazed changed during summer so that stocking density in mid- to late-summer was 37.5 to 50 % lower than the stocking density in late spring. In the year-round system, yearling cattle grazed smooth bromegrass-orchardgrass-birdsfoot trefoil pastures with cow-calf pairs in early summer so that stocking density in August through October was 33% lower than during the first 50 d of grazing in May and June. When cool-season grass decreased in mid-summer, cow-calf pairs in the year-round grazing system were 'taken' from the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures and 'put' on a mixture of first- and second-cutting or only second-cutting tall fescue-red clover or smooth bromegrass-red clover pastures while yearling cattle continued to graze the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures. As a result of these management practices, peak herbage masses in the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land and year-round grazing systems were 2.2 and 2.7 times the initial herbage masses, respectively. Peak herbage masses have been reported to be 1.5 to 1.9 and 1.2 to 1.6 times greater than initial values in grass or grass-legume pastures grazed at set stocking rates in previous studies (Tallowin et al., 1986; Beck and Russell, 1991). Because of the control of forage growth and stocking density, forage allowance did not fall below the allowance or 10 kg/100 kg BW at which animal production may be adversely affected (Marsh, 1979) or 5 kg/100 kg BW at which forage intake may be adversely affected (NRC, 1996). Seemingly, because of control of forage mass by either system, senescence of the forage was prevented. The mean proportion of total DM that was live at the termination of grazing in fall ranged from 39.3% in yr 1 to 81.2% in yr 2 compared to values of 43 to 70% reported in studies in which set stocking rates were used (Beck and Russell, 1991). Seemingly, in association with this prevention of senescence, control of forage mass by either system prevented the decrease in IVDMD concentration during the grazing season observed in other studies (Grings et al., 1996; Western, 1997). The concentration of forage in the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the minimal land system increased from 55% at the initiation of summer grazing to 66% in October. Likewise, the IVDMD concentration of forage in the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in the year-round grazing system increased from 57% at the initiation of grazing to 68% in October. In contrast, CP concentrations of the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures decreased from 15.7% at the initiation of grazing to 12.0% in October.

Mean forage masses at the initiation of grazing of the tall fescue-red clover and smooth bromegrass-red clover pastures by cows, calves and bulls in the year-round system in June differed little from the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in either system. Much of this effect resulted from differences in yr 1 when cows, calves, and bulls initially grazed first harvest forage on 25% of the area these pastures. Initial grazing of first harvest forage in yr 1 also likely resulted in the lower IVDMD concentration of the tall fescue-red clover and smooth bromegrass-red clover forages than the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures. Forage masses of the second-harvest tall fescue-red clover and smooth bromegrass-red clover pastures were lower than those of the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in either system in June and July. Forage allowances were still above those reported as limiting animal production or forage intake

(Marsh, 1979; NRC, 1996). Concentrations of IVDMD of forage in the second-harvest tall fescue-red clover and smooth bromegrass-red clover pastures did not differ from forage in the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in July, but were lower than forage in the smooth bromegrass-orchardgrass-birdsfoot trefoil pastures in August possibly because of a continuing low herbage mass. The herbage mass remaining in the tall fescue-red clover and smooth bromegrass-red clover pastures in August represented 45 and 44% of the stockpiled forage masses present in November.

Seemingly, because of the effects of the forage management systems on forage mass and nutritional value, mean ADG of calves over the 3 yr was over 1 kg/d for cow-calf pairs in both the minimal land and year-round grazing with midsummer tall fescue-red clover. In contrast, mean ADG of calves in the year-round grazing system with midsummer smooth bromegrass-red clover was .96 kg/d. The reason for this lower calf BW gain is not readily apparent. Cows were reallotted in November of each year and, therefore, cow effects should not have occurred. Herbage masses for pastures in the year-round grazing system with midsummer smooth bromegrass-red clover were generally lower than the other systems. However, the differences in herbage masses between systems were not always significant and forage allowances were always above the level of 10 kg/100 kg BW recommended by Marsh (1979). Seasonal calf production, expressed as kilograms per hectare, was greater in the minimal land system than in the year-round grazing system. Although yearling animals were utilized in the year-round grazing systems primarily for early season forage management, their production also provides additional animal gain from the land base. Addition of yearling gains to those of the calves increased growing animal production in the year-round grazing system, but not to the level of the minimal land system. The difference in growing animal production between systems is entirely caused by differences in the amounts of land in perennial forages used in the minimal land (1.01 ha/cow-calf pair) and the year-round grazing (2.02 ha/cow-calf pair) systems.

In addition to providing pasture forage for grazing during summer, forage systems must also supply winter forage. Mean net forage production from the minimal land system was 1,272 kg DM/cow. Winter forage requirements of these cows were 2,869 kg DM/cow (Hersom et al., 2000). Because of the shortfall in hay production in the minimal land system, an additional 1.88 ha of land area would be required for adequate hay production. Incorporation of the additional land area into the calculation of seasonal growing animal production results in a 3-yr mean of 130.1 kg/ha which is nearly equal to that observed in the year-round grazing systems.

As a result of the BW gains of .19 and 1.53 kg/d achieved by yearling cattle in the year-round grazing system during the winter backgrounding and summer grazing periods, the yearling cattle required 84 fewer days in the feedlot to finish than calves from the minimal land system that were placed directly in a feedlot after weaning. This difference in days spent in the feedlot did not result in a significant reduction in the amount of concentrates to finish these calves to an equal backfat thickness. Furthermore, forage DM used during the backgrounding and finishing periods by calves in the year-round grazing system was 1.97 times greater than calves in the minimal land system. Efficiencies of use of concentrates and total stored feeds did not differ between systems. The lack of significance in the differences in feed consumptions and efficiencies may have partially resulted from the lack of replication of lots within year, thereby requiring the use years as replicates in the statistical analysis of the data. Similar to feedlot performance, carcass characteristics of animals in the year-round grazing system were not different to those of animals in the minimal land system, implying that there were no effects of backgrounding and summer grazing on carcass quality provided that the animals were finished on grain to an equivalent backfat thickness.

The ADG of yearling cattle in the year-round grazing system while grazing over 91 to 101 d were greater than those observed in similar studies (Klopfenstein et al., 1987; White et al., 1987; Lewis et al., 1990). The differences in performance may have resulted from the quantity and nutritional quality of forage available as related to forage species, grazing management, length of the grazing period or stocking densities and/or the compensatory growth response of the cattle (Horton and Holmes, 1978). Contrary to the results of Fox et al. (1972), cattle from the Year-round grazing system in this experiment did not seem to exhibit compensatory gains in the feedlot, especially in light of the lack of differences in the amounts of concentrates fed, feed efficiencies and carcass characteristics between cattle in the Year-round grazing and Minimal land systems.

Implications

These data imply that a system of grazing cow-calf pairs in which pasture stocking density is increased by grazing growing cattle early in the grazing season in combination with hay harvest improves in vitro dry matter disappearance of late-season pasture forage to an equivalent extent, increases net forage production, and results in equivalent growing animal production compared to a system in which excess forage is removed by hay alone if the land area in the later system is adjusted to meet the winter hay needs of the cows. Grazing of yearling cattle after a period of winter backgrounding did not reduce the amounts of concentrates needed to finish cattle to a comparable backfat compared to cattle placed in a feedlot at weaning.

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GENERAL CONCLUSIONS

The objective of this experiment was to evaluate three year-round forage management systems for the production of beef. Forage production, nutritive value, hay feeding and cow-calf and yearling cattle production during both winter and summer were measured and used to compare the three systems. During the winter, body weights and body condition score did not differ between cows that sequentially grazed corn crop residues followed by stockpiled tall fescue-red clover or smooth bromegrass-red clover and maintained in drylots. This result is because that body weight and body condition scores changes were relatively small for cows grazing corn crop residues. Thereafter, cows grazing stockpiled forages were able to maintain body weight throughout the rest of the winter and regained lost body condition after March. In March, stockpiled forages provided adequate herbage allowances of sufficient quality to allow cows to increase body condition during a period when nutrient requirements increase because of pregnancy and the following lactation. These findings were in contrast to predictions based the NRC Nutrient Requirements for Beef Cattle Program (NRC, 1996) which predicted that cows grazing tall fescue should lose 1.0 unit of body condition and cows grazing smooth bromegrass should gain 1.0 unit of body condition while cows in the drylot lost body condition at two times the rate predicted. Therefore, it was observed that forages initially stockpiled in August with nitrogen fertilization maintained adequate herbage masses and quality to maintain gestation, and thereafter cows in early lactation. Because of the success of the stockpiled forages in the wintering systems, cows grazing stockpiled forages had supplemental hay requirements which were 2,670 to 2,715 kg DM/cow less than cows maintained in drylots. These hay savings in stockpiled forage grazing systems would have provided for maintenance of another cow in the drylot. Overall, the use of corn crop residues and stockpiled forages for winter management reduced the amount of stored forage that was required to maintain gestating beef cows during the winter.

The inclusion of stockpiled forage pastures for winter use causes an excess amount of forage during the summer in addition to forage already produced during the summer that must be addressed the in the year-round forage management systems. Because of the increased nutritional needs of cows for lactation and reproduction and calf growth, forages during the summer need to be managed in order that adequate, quality herbage masses are maintained. In addition forage production for winter use occurs during the summer. Early spring excess forage in summer smooth bromegrass-orchardgrass-birdsfoot trefoil pastures and tall fescue-red clover or smooth bromegrass pastures were managed by increasing the stocking density with yearling stocker animals in summer pastures and harvesting hay and grazing from tall fescue-red clover and smooth bromegrass-red clover pastures in the Year-round grazing systems. In the Minimal land grazing system, hay harvest was utilized to remove excess spring forage. Both management systems maintained adequate herbage allowances and herbage quality. Herbage masses and quality varied in tall fescue-red clover and smooth bromegrass-red clover pastures during the summer because of the hay and grazing management practices. Hay production on a per cow basis was greater on Year-round grazing system tall fescue-red clover and smooth bromegrass-red clover pastures than the Minimal land grazing system smooth bromegrass-orchardgrass-birdsfoot trefoil pastures. In addition to greater hay production, forage produced on tall fescue-red clover and smooth bromegrass-red clover pastures for stockpiling amounted to winter forage production in the Year-round grazing systems of 5.4 and 5.3 times as much forage DM/cow than produced in the Minimal land grazing system. Cow body weight and body condition scores were similar between Year-round and Minimal land grazing systems throughout the summer. Rebreeding rates among cows was acceptable however, a trend of longer calving intervals was observed. This increase of the calving interval could not be explained by any measurements of herbage mass, allowance, or quality. Production of seasonal gain of calf and growing animal were greater on the Minimal land than the Year-round grazing systems because of the different amounts of land utilized between the two grazing systems. A comparison of yearling animals that grazed during the summer followed by feedlot finishing to that of animals placed in feedlot directly resulted in no difference in carcass characteristics. However, animals that grazed during the summer required fewer days in the feedlot than those placed there directly. In addition, animals that grazed during the summer required more hay because of the winter background period. Efficiencies of gain for hay, concentrates and total gain tended to be greater for animals placed directly into a feedlot. Generally, the Year-round and Minimal land forage systems maintained cows in equal body weight, body condition scores, and had calves that gained equally. However, because of the lesser land area in the Minimal land system, growing animal production per hectare was greater in the Minimal land system. Summer pasture herbage production and quality varied because of the timing of grazing and hay production throughout the summer. The inclusion of pastures for the production of stockpiled forage for winter use increased the excess spring forage, but this forage was utilized for hay production that could be used during the winter or sold.

With the conclusion of this research several questions should be addressed. The first question would how to deal with the large amount of excess forage produced in the Year-round grazing systems. Because of the amount of stockpiled forage that is grown during the stockpiling period, the hay harvested during the summer is not needed for those systems.

Secondly, the shortfall of winter forage production in the Minimal land system should be considered. In a real-life production situation, a shortage of hay for winter would either necessitate reduction in the number of cows or purchasing of stored feeds. In which case the use of other types of stored feeds could possibly be examined in an attempt to reduce the loss of body weight and body condition score that cows in the Minimal land drylots experienced. The lengthening of the calving interval each year is one that raises concerns because in real-life production systems this would be unacceptable. It is unclear whether the solution is to just start the breeding season earlier or if there is actual grazing system effects occurring that were not observable by the methods utilized in this experiment. Finally, the lack of within year replication for yearling animals in the feedlot presents concerns. Because of the small numbers of animals utilized animals in each system were group fed. This is especially problematic in the Year-round grazing systems where two different systems were used but all yearling animals were fed together. Differences may become significant if a greater number of animals and/or replications were used. An obvious omission from this body of work is that of economical analysis. While this experiment presents beef production system data that can readily be applied in real-life production it will not however, realize its' full potential without economic analysis.

APPENDIX A: WINTER DATA

Initial body condition scores and body condition score changes of cows in three winter forage systems

	Forage system			
	CCR/TF-RC	CCR/SB-RC	ML	SEM [d]
Body condition score, 9 pt scale				
Initial				
1995	4.95	4.90	4.50	.10
1996	5.20	5.30	5.05	.15
1997	5.80	5.70	5.85	.04
Avg.	5.32	5.30	5.13	.06
		Body condition change		
Period 1 [a]				
1995	-.05[b]	-.15[c]	.55[b]	.06
1996	-.70	-.50	-.20	.15
1997	-.70	-.95[b]	-.05[c]	.11
Avg.	-.48[b]	-.53[b]	.10[c]	.07
Period 2				
1995	.10	-.20	-.10	.14
1996	-.50	-.70	.08	.14
1997	-.50	-.65[b]	-.35[c]	.02
Avg.	-.30	-.52	-.13	.07
Period 3				
1995	0.0[b]	0.0[b]	-.60[c]	.07
1996	1.05[b]	.60[b]	-.23[c]	.10
1997	.40[b]	.80[b]	-.30[c]	.07
Avg.	.48[b]	.47[b]	-.38[c]	.03
Seasonal change				
1995	.05	-.35	-.15	.07
1996	-.15[b]	-.60[cd]	-.35[e]	.10
1997	-.80	-.80	-.30	.07
Avg.	-.30	-.58	-.27	.03

[a] Period 1: Yr 1;10/26/95 – 12/20/95, Yr 2; 11/1/96 – 12/26/96, Yr 3; 10/29/97 – 12/30/97.
Period 2: Yr 1; 12/21/95 – 3/7/96, Yr 2; 12/27/96 – 3/10/97, Yr 3; 12/31/97 – 3/25/98.
Period 3: Yr1; 3/8/96 – 5/1/96, Yr 2; 3/11/97 – 5/7/97, Yr 3; 3/26/98 – 4/29/98.

[b c] Means with different superscripts are significant ($P < .05$).

[d] n = 6.

Stored hay use of cows in three winter forages systems during different periods during the winter

	Winter system									
	Drylot			CCR/TF-RC			CCR/SB-RC			
Period[a] and yr	1995	1996	1997	1995	1996	1997	1995	1996	1997	SEM[b]
Summer	0	269^{c}	0	0	0^{d}	0	0	0^{d}	0	5.28
Period1	920^{c}	1,144^{ac}	930^{c}	110^{d}	0^{d}	0^{d}	111^{d}	0^{d}	0^{d}	5.28
Period2	1,122^{c}	986^{c}	1,201^{c}	178^{d}	0^{d}	18^{d}	178^{d}	0^{d}	29^{d}	5.28
Period3	773^{c}	1,027^{c}	314^{c}	78^{d}	51^{d}	30^{d}	164^{d}	52^{d}	63^{d}	5.18
Total	2,815^{c}	3,426^{c}	2,448^{c}	365^{d}	51^{d}	48^{d}	452^{d}	52^{d}	92^{d}	5.56

[a] Period 1 = corn crop grazing period, Period 2 = stockpiled forage grazing prior to calving, Period 3 = stockpiled forage grazing after calving.
[b] SEM, n = 18.
[c,d] Means with different superscripts are within year are significant ($P < .05$).

Dry matter recovery and chemical composition of hay harvested in each year from pastures of tall fescue-red clover and smooth bromegrass-red clover

	Forage species (f) and year (y)									
	Tall fescue-red clover			Smooth bromegrass-red clover				Significance [a]		
	1995	1996	1997	1995	1996	1997	SEM	f	y	f * y
	December hay sampling									
% DM recovered	93.15	99.40	105.68	95.98	101.41	105.75	.40	NS	<.01	NS
DM weight recovered	84.36	100.69	102.89	91.47	97.95	107.40	.55	.02	<.01	NS
% OM recovered	-	100.50	99.97	-	100.06	99.85	.17	NS	NS	NS
% IVOMD recovered	-	82.42	85.13	-	95.81	89.34	1.74	<.01	NS	.04
OM	92.47	90.76	90.92	92.32	91.24	91.69	.07	NS	<.01	NS
IVOMD	49.62	57.02	54.20	46.30	61.37	56.47	.80	NS	<.01	.08
NDF	59.04	58.55	61.55	62.29	66.28	63.51	.30	<.01	.05	<.01
ADF	41.44	42.16	34.35	35.28	45.42	33.10	.57	.06	<.01	<.01
CP	12.12	14.51	14.14	11.85	10.54	12.34	.45	NS	.01	.06
ADIN	8.76	8.71	11.04	7.09	7.26	7.94	.22	.03	.01	NS
	March hay sampling									
% DM recovered	96.28	95.44	99.14	98.05	98.11	96.15	.46	NS	NS	<.01
DM weight recovered	94.57	100.29	102.90	99.95	95.49	107.58	.74	NS	<.01	.01
% OM recovered	-	99.95	99.67	-	100.58	99.33	.16	NS	.04	NS
% IVOMD recovered	-	84.0	95.14	-	97.25	94.22	3.90	NS	NS	NS
OM	92.61	90.13	92.49	93.08	91.28	91.87	.11	NS	<.01	.02
IVOMD	51.42	56.70	58.46	45.53	64.74	55.92	1.61	NS	.02	NS
NDF	57.76	57.94	62.89	63.67	63.20	66.55	.29	<.01	<.01	NS
ADF	44.13	40.17	33.34	36.27	40.77	34.08	.48	.03	<.01	<.01
CP	12.85	12.98	14.64	12.05	11.38	11.91	.32	NS	.03	NS
ADIN	9.93	8.39	7.67	7.99	6.49	8.89	.17	.01	.01	<.01

[a] f = forage species, y = year, g = effect of grazing, NS = not significant ($P < .10$).

APPENDIX B: SUMMER DATA

Yearly initial cow body weight and body weight change of cows in three summer forage systems.

Item and year	Forage systems: Minimal land	Forage systems: Year-round / TF-RC	Forage systems: Year-round / SB-RC	SEM[a]
Body weight, kg				
Initial				
1996	509	519	511	6.3
1997	519	493	492	8.4
1998	533	518	531	5.1
Avg.	520	510	511	4.2
		Body weight change, kg		
Pre-breeding				
1996	12	17	15	2.8
1997	26	21	32	4.8
1998	11	16	16	4.6
Avg.	16	18	21	1.8
Breeding				
1996	15	8	11	2.4
1997	-2[b]	13[b]	19[b]	1.4
1998	-3	8	3	4.3
Avg.	4[b]	10[bc]	11[c]	1.0
Post-breeding				
1996	17	27	10	4.7
1997	19	-6	11	3.5
1998	22	5	14	2.9
Avg.	20	14	12	2.0
Season change				
1996	45	53	35	4.5
1997	44	45	45	5.9
1998	31	29	32	4.9
Avg.	40	42	44	2.1

[a] SEM n = 8.

[b,c] Means with different superscripts differ $P < .05$.

Yearly initial cow body condition score and body condition score change of cows in three summer forage systems.

Item and year	Forage systems: Minimal land	Year-round / TF-RC	Year-round / SB-RC	SEM [a]
Body condition score, 9 point scale				
Initial				
1996	4.20[b]	5.10[c]	4.60[bc]	.13
1997	4.72	5.05	5.13	.17
1998	5.08	5.25	4.90	.16
Avg.	4.67	5.13	4.86	.10
		Body condition score change		
Pre-breeding				
1996	.73	.35	.65	.14
1997	.72	.60	.42	.16
1998	.48	.75	.45	.11
Avg.	.64	.57	.51	.09
Breeding				
1996	.10	.05	.05	.13
1997	-.10	-.25	.19	.14
1998	.45	.10	.85	.14
Avg.	.15	-.03	.36	.10
Post-breeding				
1996	.06[b]	-.30[b]	-.40[c]	.14
1997	.57	.25	-.18	.13
1998	-.33	.10	-.55	.19
Avg.	.10	.02	-.36	.12
Season change				
1996	.96	.10	.35	.17
1997	1.19	.60	.43	.15
1998	.6	.25	.75	.19
Avg.	.92	.32	.51	.10

[a] SEM n = 8.

[b,c] Means with different superscripts differ $P < .05$.

Yearly rebreeding rate and calving intervals of cows in three summer forage systems.

Item and year	Forage systems			SEM [a]
	Minimal land	Year-round / TF-RC	Year-round / SB-RC	
% Pregnant				
1996	88	100	100	4.0
1997	100	80	100	4.5
1998	94	90	100	4.1
Avg.	94	90	100	2.7
Calving interval				
1996	376	360	363	2.6
1997	370	375	374	3.3
1998	382	387	389	1.8
Avg.	376	374	375	1.2

[a] SEM n = 8.

Monthly dry matter yields of summer smooth bromegrass-orchardgrass-birdsfoot trefoil pastures of minimal land, year-round/TF-RC, and year-round/SB-RC systems.

	Forage system (f) and year (yr)																		
	Minimal land			Year-round / TF-RC						Year-round / SB-RC									
Month[a]	SB-OG-BT			SB-OG-BT			TF-RC			SB-OG-BT			SB-RC				Significance		
and yr	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998	SEM[a]	yr	f	yr*f
1	768	1,381	1,769	994	1,241	1,735				789	1,172	1,655				45.6	<.01	NS	NS
2	1,282	3,517	3,285	1,222	2,468	2,330				820	3,074	2,698				99.8	<.01	.01	.01
3	1,213	2,475	1,958	1,692	2,310	3,936	2,755	2,236	1,915	1,462	2,340	3,394	2,003	1,522	2,081	74.6	<.01	<.01	.01
4	1,123	1,744	3,068	1,308	1,809	3,287	1,074	1,823	1,253	1,827	1,378	3,528	798	1,248	965	76.1	.03	<.01	<.01
5	1,335	2,930	2,911	1,727	4,120	1,930	1,136		1,725	1,328	2,454	1,865	1,053		1,400	79.8	<.01	.06	.01
6	1,557	2,774	2,841	1,493	2,765	3,491				1,291	2,534	3,341				78.1	<.01	NS	NS
7	1,350	2,242	2,885	1,109	1,905	3,157				1,203	2,042	2,758				101.5	<.01	NS	NS

[a] Month 1, 2, 6, 7 n = 24, month 3, 4 n = 36, month 5 n = 28.

Monthly growth and utilization of smooth bromegrass-orchardgrass-birdsfoot trefoil summer pastures of minimal land, year-round/TF-RC, and year-round/SB-RC grazing systems.

	Forage system (f) and year (yr)												
	Minimal land			Year-round / TF-RC			Year-round / SB-RC				Significance		
Item and month	1996	1997	1998	1996	1997	1998	1996	1997	1998	SEM [a]	yr	f	yr * f
Growth, kg/ha													
1	1,751	1,652	1,474	1,938	963	1,677	2,261	1,983	863	410.7	NS	NS	NS
2	1,011	1,763	2,152	661	1,428	1,238	1,092	1,763	1,880	263.4	NS	NS	NS
3	294	395	2,906	196	-303	1,342	476	753	2,366	165.9	<.01	.05	NS
4	678	1,153	839	1,144	1,540	2,145	419	1,706	649	101.1	.06	NS	NS
5	441	1,161	1,255	352	59	963	-88	435	2,095	194.6	.09	NS	NS
6	433	677	1,201	394	-452	452	771	-120	-177	126.8	NS	NS	NS
Utilization, %													
1	-7.45	-14.20	5.85	41.26	20.92	39.79	19.20	33.63	22.74	4.35	NS	NS	NS
2	67.50	63.79	70.17	61.11	33.51	32.69	60.18	25.90	61.64	4.82	NS	.03	NS
3	62.33	74.26	59.10	69.64	81.59	32.07	49.56	62.89	61.11	1.88	.03	NS	.04
4	54.83	34.13	63.94	37.19	12.14	55.07	65.34	53.69	54.57	2.37	.01	<.01	NS
5	51.47	58.78	59.57	64.92	63.82	52.13	64.38	61.46	57.44	2.44	NS	NS	NS
6	57.83	66.38	60.32	62.14	71.20	55.84	54.50	60.42	57.69	2.89	NS	NS	NS

[a] SEM, n = 24.

Forage allowance of smooth bromegrass-orchardgrass-birdsfoot trefoil, tall fescue-red clover and smooth bromegrass-red clover pastures during the summer.

Month and yr	Minimal land SB-OG-BT 1996	Minimal land SB-OG-BT 1997	Minimal land SB-OG-BT 1998	Year-round / TF-RC SB-OG-BT 1996	Year-round / TF-RC SB-OG-BT 1997	Year-round / TF-RC SB-OG-BT 1998	Year-round / TF-RC TF-RC 1996	Year-round / TF-RC TF-RC 1997	Year-round / TF-RC TF-RC 1998	Year-round / SB-RC SB-OG-BT 1996	Year-round / SB-RC SB-OG-BT 1997	Year-round / SB-RC SB-OG-BT 1998	Year-round / SB-RC SB-RC 1996	Year-round / SB-RC SB-RC 1997	Year-round / SB-RC SB-RC 1998	SEM [a]	Significance yr	Significance f	Significance yr * f
May	5.3	9.7	12.4	4.7	16.7	8.5				3.9	16.1	7.7				2.71	<.01	NS	<.01
June	8.0	22.2	12.3	12.7	26.2	27.6	15.7	17.3	11.9	12.2	18.3	31.8	19.2	11.6	8.9	6.14	.05	.05	.01
August	6.4	10.2	15.4	14.1	23.9	35.9	14.3	15.8	16.9	19.8	24.9	36.4	9.5	11.9	16.1	8.53	<.01	<.01	.01
October	6.7	11.0	9.3	5.7	9.9	9.3				6.1	10.8	8.2				4.58	.01	NS	NS

(Column group heading: Forage system (f) and year (yr))

Monthly in vitro dry matter disappearances of summer smooth bromegrass-orchardgrass-birdsfoot trefoil pastures of minimal land, year-round/TF-RC, and year-round/SB-RC systems.

Month and yr	Forage system (f) and year (yr)															SEM[a]	Significance		
	Minimal land			Year-round / TF-RC						Year-round / SB-RC									
	SB-OG-BT			SB-OG-BT			TF-RC			SB-OG-BT			SB-RC						
	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998		yr	f	yr * f
1 (n = 24)	61.6	50.7	53.6	65.5	48.5	55.9				62.3	52.0	58.6				1.16	.01	NS	NS
2 (n = 24)	63.4	56.0	53.5	65.6	67.9	50.0				72.3	76.1	50.0				.56	<.01	<.01	<.01
3 (n = 36)	74.3	74.9	48.4	68.3	73.6	47.8	67.4	53.1	55.5	67.3	72.4	47.6	63.5	57.2	54.2	.53	<.01	NS	NS
4 (n = 36)	70.9	77.5	48.9	70.3	66.2	49.1	66.9	69.3	48.9	72.8	68.7	47.9	68.6	70.3	50.6	.72	<.01	NS	NS
5 (n = 28)	63.4	73.9	47.6	70.1	69.9	52.3	70.8		50.9	70.2	71.3	51.2	79.9		50.2	.74	<.01	NS	NS
6 (n = 24)	65.1	83.6	46.4	70.9	79.3	45.1				67.6	83.3	41.8				1.33	<.01	NS	NS
7 (n = 24)	78.5	73.1	47.4	74.3	77.4	45.1				86.9	76.4	40.1				.82	<.01	NS	.04

Monthly crude protein concentrations of summer smooth bromegrass-orchardgrass-birdsfoot trefoil pastures of minimal land, year-round/TF-RC, and year-round/SB-RC systems

Month and yr	Forage system (f) and year (yr)															SEM	Significance		
	Minimal land			Year-round / TF-RC						Year-round / SB-RC									
	SB-OG-BT			SB-OG-BT			TF-RC			SB-OG-BT			SB-RC						
	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998		yr	f	yr * f
1 (n = 24)	15.4	15.5	15.5	14.9	14.6	16.6				16.7	16.3	15.4				.34	NS	NS	NS
2 (n = 24)	11.5	11.1	13.2	12.2	12.1	11.5				11.3	10.8	10.8				.29	NS	NS	NS
3 (n = 36)	11.3	10.2	9.6	11.8	12.1	14.3	12.5	13.1	12.3	12.7	11.9	14.4	11.4	12.1	10.3	.23	NS	.01	NS
4 (n = 36)	15.0	11.5	15.9	14.6	13.3	14.5	11.5	12.1	12.7	12.2	11.3	15.0	12.9	12.3	14.1	.45	.08	NS	NS
5 (n = 28)	15.4	12.6	13.3	12.1	14.7	13.9	14.1		14.9	14.4	12.5	12.1	11.9		11.5	.18	NS	NS	.01
6 (n = 24)	12.8	13.3	13.3	10.6	13.7	12.8				12.7	12.9	14.2				.30	NS	NS	NS
7 (n = 24)	11.2	11.8	13.4	11.6	11.4	14.9				10.8	11.4	12.9				.24	NS	<.01	NS

Monthly NDF concentrations of summer smooth bromegrass-orchardgrass-birdsfoot trefoil pastures of minimal land, year-round/TF-RC, and year-round/SB-RC systems.

	Forage system (f) and year (yr)																		
	Minimal land			Year-round / TF-RC						Year-round / SB-RC									
Month	SB-OG-BT			SB-OG-BT			TF-RC			SB-OG-BT			SB-RC				Significance		
and yr	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998	SEM	yr	f	yr * f
1 (n = 24)	49.8	45.3	51.7	51.1	43.2	46.9				49.2	44.5	47.8				.48	<.01	NS	NS
2 (n = 24)	57.8	54.3	57.4	56.7	48.8	55.5				58.6	53.9	57.2				.65	NS	NS	NS
3 (n = 36)	58.8	60.8	59.1	55.6	57.5	55.5	55.8	57.6	58.8	58.4	58.9	53.8	57.1	60.1	58.6	.52	NS	.06	NS
4 (n = 36)	55.5	60.3	55.2	55.1	55.6	55.3	56.7	57.8	56.4	59.6	59.3	56.1	54.7	57.0	54.9	.60	NS	NS	NS
5 (n = 28)	53.5	59.2	53.9	56.9	55.1	54.7	54.4		52.2	57.1	59.1	54.4	57.5		59.5	.35	.01	NS	NS
6 (n = 24)	55.3	61.2	57.3	58.8	58.3	58.6				54.4	60.3	57.5				.32	<.01	NS	.06
7 (n = 24)	59.3	55.7	54.7	60.4	55.9	52.9				60.0	56.6	56.3				.41	<.01	NS	NS

Monthly ADF concentrations of summer smooth bromegrass-orchardgrass-birdsfoot trefoil pastures of minimal land, year-round/TF-RC, and year-round/SB-RC systems.

	Forage system (f) and year (yr)																		
	Minimal land			Year-round / TF-RC						Year-round / SB-RC									
Month	SB-OG-BT			SB-OG-BT			TF-RC			SB-OG-BT			SB-RC				Significance		
and yr	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998	1996	1997	1998	SEM	yr	f	yr * f
1 (n = 24)	29.4	26.1	31.4	30.7	25.5	30.8				27.8	27.7	26.9				.68	NS	NS	NS
2 (n = 24)	36.1	32.6	34.6	36.8	37.9	38.9				39.1	40.9	38.8				.29	NS	<.01	NS
3 (n = 36)	34.6	40.0	39.4	38.7	40.3	37.9	34.2	31.0	34.4	36.3	38.3	37.0	35.3	31.2	33.7	.32	<.01	<.01	<.01
4 (n = 36)	35.5	40.6	36.1	35.1	36.8	38.2	23.3	37.1	33.6	37.8	36.6	40.2	29.9	36.5	32.2	.43	NS	NS	NS
5 (n = 28)	32.3	38.1	37.5	34.7	37.9	34.4	35.5		37.6	32.0	37.5	34.3	37.3		36.1	.41	<.01	NS	.07
6 (n = 24)	35.8	40.0	39.2	33.8	37.9	41.5				36.1	39.8	41.2				.48	<.01	NS	NS
7 (n = 24)	37.9	36.5	37.3	38.7	37.7	39.5				37.9	38.3	39.7				.42	NS	NS	NS

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